Field Procedures Manual

National Oceanic and Atmospheric Administration, Office of Coast Survey

April 2009

FOREWORD

The purpose of this Field Procedures Manual (FPM) is to provide NOAA field units with consolidated and standardized guidelines and requirements for conducting, processing, and generating final field deliverables for Office of Coast Survey (OCS) hydrographic surveys. This manual summarizes current best practices that shall be used by NOAA field units to meet specifications set forth in the NOS Hydrographic Surveys Specifications and Deliverables.

Words used in this manual to denote mandatory or permissive actions are defined as follows:

- “Shall” or “must” means the procedure or standard is mandatory.
- “Should” means the procedure or standard is recommended.
- “May” and “need note” means that the procedure or standard is optional.
- “Will” means futurity of action only and does not indicate any degree of requirement for application of a procedure or meeting a standard.

Due to the rapid development of technology and continual improvement of operational methods, the FPM will require periodic maintenance. User input, particularly from field units, is critical to ensuring that the FPM is up to date. Recommended changes to the FPM will be reviewed by committee bi-annually for potential application to the FPM. Any new procedures put into effect between versions of the FPM will be implemented via a Hydrographic Surveys Technical Directive. Recommended changes and other comments regarding the manual should be forwarded via email to FPMupdates@noaa.gov.

Any mention of a commercial company or product within this manual does not constitute an endorsement by NOAA. The use for publicity or advertising purposes of information concerning proprietary products or software or the tests of such products is not authorized.

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SIGNIFICANT FPM CHANGES SINCE RELEASE OF MAY 2008 VERSION

SECTION	DESCRIPTION OF CHANGE
1.4.3 Wiring Diagrams	This is a new section to communicate that all field units should maintain up-to-date wiring diagrams for each of their survey vessels.
2.2 The Project CD/DVD	This section has been updated with a new subsections for (1) Historic Preservation Correspondence and (2) Monthly Reports and has been rearranged slightly.
2.2.2.6.1 Junctioning with Light Detection and Ranging (LIDAR) Surveys	This section was updated extensively to clarify the files provided to field units from the Hydrographic Surveys Division.
2.2.2.8 Monthly Reports	This section title has been renamed from ’Progress Sketch and Stats Files’ to reflect the new methodology for reporting survey progress, statistics, and vessel utilization.
2.5.4 Survey Polygon Planning	This is a new section. The parent section 2.5 has been slightly reorganized to acommodate this new guidance.
3.5.2.3.3 fetchtides	A new subsection on fetchtides has beed added along with a reference to the fetchtides user manual that is now part of the chapter 3 appendix. fetchtides is a procedural program which allows a user to retrieve tides data from a variety of sources including data e-mailed from tidebot, data in local files, and live data available through CO-OPS’s Web Services
3.5.5.1 Source Shoreline Data	The new Project Reference File (PRF) and the features contained within it are described here.
4.2.3.8.1 Field Sheet and Grid Size Guidance	A new subsection has been added to provide practical guidance from the Atlantic Hydrographic Branch on physical size and computer file size for grids and field sheets.
4.4.5 Cultural or Historic Sumberged Features	This section has been updated to include new procedures (taken from HTD 2008-9) for obtaining historic consultation for data sets submitted to HSD. In general, NOAA Field Units are no longer required to submit any data to the National Marine Sanctuaries Program or a State Historic Preservation Officer as required of the previous edition of this manual.That task will be the responsibility of the Atlantic and Pacific Hydrographic Branches.
4.4.6 Pydro Feature Classification	A URL to an up-to-date Field & Branch Features Encoding Guide for the West coast and Alaska has been added in this section.
4.4.10.1 Feature Reporting (Notebook) – Required Files	Aspects of the ’Field Verified’ and ’Disprovals’ layers in the Composite Source are clarified.
5.2.3.2.1 Monthly Survey Progress Estimates, Project Statistics, and Vessel Utilization Reports	This section has been updated to reflect the new method and format, described in Hydrographic Technical Directive 2009-1, for reporting monthly survey progress to the Hydrographic Surveys Division.

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Chapter 1

Systems Preparation & Maintenance

> Action springs not from thought, but from a readiness for responsibility. – Dietrich Bonhoeffer

NOAA's Office of Coast Survey (OCS) uses a wide array of systems, tools, and procedures to perform modern hydrographic surveys. Due to the variety of equipment and highly technological nature of operations, a consistent, well-documented program of systems preparation and maintenance is essential to ensure that NOAA's hydrographic field units are capable of producing data that will meet OCS specifications. These procedures can be broken down into two categories: Annual Systems Preparation and Periodic Quality Assurance.

1.1 Annual Systems Preparation

Each field unit shall schedule an adequate period of time for Annual Systems Preparation, typically during winter inport for ships, in which survey systems will undergo annual calibration, maintenance, and verification procedures as defined in this chapter. These procedures should also be performed following any significant period of inactivity and after major changes or upgrades to a field unit's hydrographic systems. Unless specifically stated otherwise or assistance is arranged from another NOAA office, Systems Preparation should be conducted and documented by field unit personnel.

As a final step in Annual Systems Preparation, prior to the start of survey data acquisition, each field unit shall perform a Hydrographic Systems Readiness Review as described in section 1.1.1 This process is simply a formal review of each hydrographic field unit's Annual Systems Preparation.

1.1.1 Hydrographic Systems Readiness Review

The primary purpose of the Hydrographic Systems Readiness Review (HSRR) is to officially document and inform OCS senior-level management of a field unit's level of readiness to perform hydrographic surveys that will meet OCS specifications. This procedure also affords field units the opportunity to identify any deficiencies that will prevent optimal performance and production throughout the field season. These deficiencies may include such items as damaged or unreliable equipment, unmet training needs, and personnel shortages. Formally documenting field unit requirements will better prepare OCS to provide support and meet the needs of NOAA's hydrographic fleet. The Hydrographic Systems Readiness Review process can be broken down into four basic steps outlined below.

1. Hydrographic Systems Review Team Organization. A Hydrographic Systems Review Team shall be organized for each NOAA hydrographic field unit. This team shall consist of an assigned OCS Representative, typically a hydrographer from either the Atlantic Hydrographic Branch (AHB) or the Pacific Hydrographic Branch (PHB), the regional Hydrographic Systems and Technology Program (HSTP) Field Support Liaison, and the field unit's Field Operations Officer (FOO) or equivalent.

2. Hydrographic Systems Review. The Hydrographic Systems Review Team shall examine both physical survey systems and documentation for Annual Systems Preparation requirements outlined in this chapter. After completion of the review, this team shall brief the Chief-of-Party on the level of field unit readiness determined, any deficiencies identified, and any recommendations that could increase the unit's data quality or general survey efficiency.

3. Hydrographic Systems Readiness Review Memo. Within ten working days of commencing survey operations, the Chief-of-Party shall notify OCS of the field unit's hydrographic systems status and level of readiness to complete its assigned OCS hydrographic survey mission. This notification shall be an email submission consisting of a digitally signed Hydrographic Systems Readiness Review Memo (see Appendix 1) that lists system deficiencies identified during the Hydrographic Systems Review and a plan to address each problem. Any modifications or restrictions in operations that will be necessary in the interim must also be identified. This digitally signed memo should be sent to ocs.hsrr@noaa.gov. The following people receive e-mail sent to ocs.hsrr@noaa.gov:

    (a) Chief and Deputy Chief, Hydrographic Surveys Division (HSD)
    (b) Chief and Deputy Chief, Navigation Services Division
    (c) Chief, Hydrographic Systems and Technology Program
    (d) Chief, Atlantic Hydrographic Branch
    (e) Chief, Pacific Hydrographic Branch
    (f) Chief, HSD Operations Branch
    (g) Chief, NSD Navigation Response Branch

4. Hydrographic Systems Readiness Acknowledgment. Within ten working days of receiving the Hydrographic Systems Readiness Review Memo, the Chief of HSD or Chief of NSD shall formally acknowledge receipt via a digital memorandum to the field unit's Chief-of-Party with a copy to ocs.hsrr@noaa.gov. This memorandum of acknowledgment shall also state OCS acceptance, qualified acceptance, or rejection of the field unit's hydrographic systems readiness. If systems readiness is partially accepted or rejected, the memorandum shall list any specific actions required by OCS for the field unit to meet data quality standards.

1.2 Periodic Quality Assurance

Periodic Quality Assurance refers to any additional procedures required by OCS to maintain or verify continued data quality between annual Hydrographic Systems Reviews. These procedures vary by equipment type and are generally performed on a scheduled basis throughout a unit's field season. Specific requirements are organized by system type and defined in this chapter.

1.3 Basic Methods and Documentation

To effectively manage a field unit's hydrographic systems, a comprehensive inventory must first be completed, and then continually maintained. A standard format for a Hydrographic Systems Inventory has been implemented by OCS, as described in section 1.3.1 This inventory is a critical element of systems documentation for both Annual Systems Preparation and changes occurring throughout a unit's field season. Preparation and maintenance requirements will vary, typically by survey system category and type. While Periodic Quality Assurance procedures are relatively easy to manage, the sheer quantity and variety of tasks to be completed during Annual Systems Preparation can be daunting. To assist the field unit, an Annual Systems Preparation checklist has been provided in Appendix 1 (Annual_Sys_Prep_Checklist.xls). This list is not all encompassing, but is based on NOAA's collective hydrographic experience and is intended to define minimum requirements. Additional procedures may be added at the discretion of the field unit. If a field unit plans to use a system not included in this checklist for OCS hydrographic survey operations, the regional HSTP Field Support Liaison shall be contacted to assist in establishing adequate system maintenance and checkout procedures. OCS-recommended methods for meeting both Annual Systems Preparation and Periodic Quality Assurance requirements for standard hydrographic survey systems are described in detail in sections 1.4-1.7. However, unless stated that the field unit shall or must follow a specific procedure, these methods are not mandatory. Field units are encouraged to develop more efficient and/or accurate methods in consultation with HSD and HSTP personnel. Note: Any new procedures used must be documented with sufficient detail for the process to be recreated. Systems documentation shall meet the minimum guidelines set forth in this chapter and use digital reporting formats supplied in Appendix 1. Each of the forms provided in Appendix 1 has been designed to include essential information and easily convert to Adobe Portable Document Format (*.pdf) for submission. Conversion to *.pdf can be accomplished by "printing" the document with Adobe PDF selected as the printer. The bulk of systems documentation is to be maintained by the field unit and made available for review during Hydrographic Systems Reviews and at the request of OCS. Documentation designed for continual maintenance, such as the Hydrographic Systems Inventory spreadsheet, should be used to capture changes that occur throughout a field season.

1.3.1 Hydrographic Systems Inventory

Each field unit shall complete and maintain a digital Hydrographic Systems Inventory addressing the four systems categories described below. This information shall be recorded using the format provided in Appendix 1 (Hydrographic_Systems_Inventory.xls). Sample data have been entered in this spreadsheet using red font.

- Vessels - Include all vessels to be used for hydrographic data acquisition. For new vessels or platform types not commonly used in OCS hydrography, additional descriptive information with diagrams and/or pictures should be included.
- Hardware Systems - Include all hardware systems to be used to acquire hydrographic survey data.
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- Software Systems - Include all software to be used to acquire or manipulate hydrographic survey data.
- Personnel Roster - Include all personnel within the field unit who will be actively involved in survey operations.

As this inventory will typically change over the course of the field season or surveying period, the Hydrographic Systems Inventory shall be updated as changes occur and submitted as Appendix I of the Data Acquisition and Processing Report (DAPR) for each project.

Note: HSTP is currently developing an online fleet-wide systems inventory database. Once deployed, this database is expected to serve many of the same functions as the Hydrographic Systems Inventory described above. HSTP and HSD will issue instructions to field units on the use of this database when it is ready for use.

1.4 Vessels

Vessels are the most fundamental systems in hydrography. Accurate measurement of the dimensions and dynamic parameters of these platforms is essential to obtain high quality survey data. Vessel “calibration” consists of measuring, and estimating error for, static parameters such as the physical positions of instruments and equipment on a vessel, as well as dynamic parameters such as waterline and dynamic draft. Measurement, verification, and documentation of static parameters are addressed in 1.4.1. Dynamic parameters are discussed in 1.4.2.

1.4.1 Vessel Static Offsets

Static offsets of a vessel and its instrumentation are measured for the purpose of establishing a local reference frame to which all soundings and positions will be tied. Thus, errors in these measurements will directly translate to errors in survey data acquired by that vessel. Because much of the equipment installed on vessels remains fixed from year to year, it may not be necessary to perform a full survey of every platform during Annual Systems Preparation.

If the results of a previous survey are available and well documented, and the vessel’s configuration has not changed, simply verifying the existing values should be sufficient. Even when instrumentation has been moved, if the reference frame is based on a network of benchmarks independent of the movable equipment, it may be possible to reposition instruments within the fixed network rather than resurvey the entire vessel. This procedure will result in a significant savings of time and effort, but it is imperative that the original survey be completely and accurately documented to be effective.

The following items shall be positioned as part of any static offset survey conducted for a NOAA hydrographic survey platform:

- Permanent benchmarks - Benchmarks shall be sufficient in number and position to maintain the vessel reference frame if instrumentation is disturbed.
- Sonar transducers - All vertical beam echosounders, multibeam echosounders, and hull mounted side scan sonars that may be used to acquire hydrographic survey data shall be positioned. Transducers mounted on poles, levers, or other movable mounts should be surveyed in their fully deployed position. Offsets shall be measured to the transducer’s phase center, or the origin of the sonar’s local reference frame. OCS recommends also documenting measurements to a nearby permanent mounting point, for reference if the sonar head must be removed or replaced. Consult the corresponding manufacturer’s documentation for further guidance on the location of transducer phase centers.
- GPS antennae - All survey system GPS antennas shall be positioned. This includes any GPS antennas that are integrated with differential beacon receivers and typically only used for differential corrections but could potentially be used to acquire complete survey position data. Antennas capable of receiving differential correctors only do not need to

be surveyed. Offsets shall be measured to the phase center of each antenna, a point which may be located inside the antenna's housing. Consult the corresponding manufacturer's documentation to determine the phase center location of a specific antenna type. OCS recommends also documenting measurements to the permanent mounting post for reference if the antenna must be removed or replaced.

- Reference Point (RP) - A RP shall be established and positioned for each vessel. This point will define the origin of the local vessel reference frame to which all survey data will be tied. Note: OCS strongly recommends that a vessel's RP be established at the vessel's approximate center of motion (as defined below) and coincident with the origin of the IMU's local reference frame on vessels equipped with a POS/MV system. By collocating these three points, the number of physical offset measurements required will be reduced, thus minimizing sources of error in position and attitude data.
- Center of Motion (CM) - A CM shall be defined and positioned for each vessel. Establish this point at an approximate location at which the vessel's roll, pitch, and yaw axes intersect during static conditions and average loading. The location of a vessel's true center of motion will vary based on a combination of hull shape, loading conditions, and vessel speed; thus it is a dynamic point. However, a fairly accurate estimation can be made using the vessel's plans and empirical observation. Field units should contact NOAA's Marine Engineering Division (MED) for assistance when defining a vessel's RP.
- Inertial Measurement Unit (IMU) - For all vessels equipped with a POS/MV system, measurements shall be made to the origin of the POS/MV IMU's local reference frame. The manufacturer's documentation will define the IMU's local reference frame and identify its origin.
- Towpoint - If the vessel is equipped to perform towed sonar operations, the towpoint shall be positioned. The position of the towpoint is defined as the last point of contact between the tow cable and the vessel, typically the top of a sheave over which the tow cable is led. If the sonar is towed from a movable point (J-arm, A-frame, etc.), it shall be in its fully deployed position for this measurement.

1.4.1.1 Vessel Measurement Requirements & Methods

Vessel measurement procedures vary depending on whether the intent is to complete a full survey of a vessel, conduct a partial survey to position new or disturbed instrumentation within an existing reference frame, or simply verify existing offsets when no known changes have occurred. The requirements and methods for each of these scenarios are described below.

1.4.1.1.1 Full Survey A full survey of a hydrographic vessel is required when no prior survey exists or under any circumstances where all previous surveys are determined to be unusable. Full vessel surveys should be conducted by National Geodetic Survey (NGS) personnel or a professional geodetic surveyor. Full vessel surveys can be both time consuming and expensive; thus, proper documentation is important to preserve the value of this work. Examples of conditions that would require full surveys include, but are not limited to, the following:

- A vessel is new or will be engaged in hydrography for the first time.
- Significant modifications have been made to the vessel since the last full survey.
- New equipment is installed or existing equipment is repositioned, and the items cannot be accurately referenced to benchmarks from a prior survey.

- New technology or techniques become available that would significantly increase the accuracy of offset measurements or error estimates for the vessel.
- Complete documentation of the previous survey, including offset values, error estimates, and procedure descriptions, is not available.
- The hydrographer discovers blunders or unexplained discrepancies when verifying the results of a previous offset survey. See 1.4.1.1.3.
- The vessel is involved in an incident, such as a grounding, that has altered the positions of benchmarks and instrumentation, affecting the validity of the previous survey.

The goal of a full survey is to establish a completely new three dimensional local vessel reference frame that is independent of any prior vessel surveys conducted. Information from existing surveys shall not be incorporated into any full survey.

General Considerations for Full Surveys

Accuracy Requirements - OCS has not defined specific numerical values for required offset measurement accuracy. However, errors introduced in the offset measurement process will be combined with errors from other sources to produce a final Total Propagated Uncertainty (TPU) (or TPE in CARIS see section 4.2.3.6) for each sounding. Measurement errors must be accurately estimated and small enough for vessel data to meet OCS survey specifications. More accurate vessel surveys will leave additional room in the error budget for other sources of error, which may allow the hydrographer to retain more data or operate under more adverse conditions than would be possible with a low accuracy survey. Note: Some integrated position and attitude sensors in use on NOAA platforms, such as the Applanix POS M/V, do have specific accuracy requirements for offset measurements between system components during installation. Hydrographers should review the manufacturer's documentation for any system-specific requirements.

Benchmarks - Benchmarks are permanent, known positions on the vessel used to identify the established local reference frame. They may be either existing points, such as antenna posts or well defined features of the vessel, or monuments specifically created or installed for the purpose of the survey. Examples of monuments are punch marks, scribe marks, or survey disks. Hydrographers shall avoid establishing vessel reference frames that utilize impermanent features of the vessel as benchmarks. Two following two factors should be considered when selecting or installing benchmarks: (1) Permanence - Benchmarks should be permanent features fixed to the vessel's hull or superstructure. Instruments are typically not appropriate benchmarks because of their potential to be moved. If points such as sensors, antennae, or transducers are used as benchmarks, the reference frame may be invalidated if the equipment is removed, replaced, or relocated. (2) Accessibility and Location - Benchmarks should be established in locations that are protected, but can be readily accessed for future surveys. OCS strongly recommends establishing benchmarks near hydrographic instruments such as sonar heads and antennae. Doing so will allow sensors to be accurately reintegrated into the network if they are moved. Since these benchmarks are used to establish a three dimensional reference frame on the vessel, three benchmarks should be readily accessible from each instrument location to accurately position sensors, regardless of vessel attitude.

Selection of a Reference Point - Every benchmark network must have a defined origin (i.e., a reference point) for the local reference frame. OCS recommends locating this point at the vessel's approximate center of motion during static conditions and average loading, as discussed in section 1.4.1.

Error Estimation - Accurate error estimates for a vessel survey are as important as the offset measurements themselves. While specific sources of error are inherent to each method of survey (see Surveying Methods below), the following common factors affect the accuracy of all vessel offset surveys.

Setups - This term refers to the number of individual measurements required to compute the relative position of two benchmarks, literally the number of times the surveyor's instruments must be set up to complete the measurement. Multiple setup measurements use intermediate points as temporary benchmarks between the two desired points. Physically positioning the measurement instrument on or over a benchmark or other reference point is a possible source of error, so multiple setups can increase the measurement error between two points. Hydrographers should attempt to minimize the number of setups required between benchmarks and record the number of setups for each leg of the survey.

Redundancy - If possible, the hydrographer should arrange the survey such that no benchmark is tied to the rest of the network by only one measurement. Ideally, each benchmark should be tied directly to multiple other benchmarks. In cases where vessel layout makes this impractical, multiple measurements along the same leg may be useful. These additional data can be used to improve the accuracy of positions generated by the survey. While redundant positions can simply be averaged, a more accurate method of determining a final value is to combine measurements using a least squares algorithm.

Total Error - When estimating the total error for one leg of a vessel offset survey, individual measurement errors are combined using a "root sum squared" method, rather than simple addition. For example, in the case of a two setup measurement, the final error estimate for the leg would be computed as follows:

$$\sigma = \sqrt{\sigma_1^2 + \sigma_2^2}$$

where σ is the standard deviation of the total measurement, σ_1 is the standard deviation of the measurement from the first benchmark to the temporary benchmark, and σ_2 is the standard deviation of the measurement from the temporary benchmark to the second benchmark.

Vessel Leveling - Although it is possible to establish a vessel reference frame that is not aligned with the vessel itself, this adds an element of complication and potential error that is best avoided. The vessel surveying process is much simpler if the vessel is removed from the water and leveled relative to the earth. For ships, this may not be possible, but launches can generally be accommodated using trailers or jack stands. If a ship is to be surveyed during a dry dock period, measurements must be corrected for the slope of the vessel on the marine railway. This angle can be determined by referencing marine growth along the ship's waterline prior to pressure washing. Subsequent offset measurements will need to be corrected for the determined angle of inclination.

Surveying Methods

For the purposes of this manual, offset measurement techniques are broken into the following two categories:

"Traditional" Methods - these methods refers to conducting a vessel offset survey using tools such as steel measuring tapes, T-squares, plumb bobs, and laser or carpenter's levels. While these instruments can yield very exact measurements, particularly on small vessels such as launches, this technique relies on the assumption that the vessel is level and true. With this method, the surveyor uses the existing planes and axes of the vessel's construction, such as the deck, door frames, and keel lines, to establish the local reference frame. Not only can significant error be introduced if the vessel is not actually level and true, it can also be more difficult to estimate error using traditional methods. OCS recommends using advanced survey methods if equipment and expertise are available.

"Advanced" Methods - these methods employ precision survey equipment such as theodolites, laser range finders, total stations, and optical levels. One advantage of using these optical techniques is that measurements are independent of the vessel's attitude and alignment. Since the surveying instrument can be positioned anywhere convenient, measurements between benchmarks can often be accomplished with a single setup, thereby minimizing error. Detailed procedures for conducting vessel surveys using advanced methods have not been established by OCS. Field units desiring a full vessel survey using advanced methods should consult the regional HSTP Field Support Liaison before proceeding. Assistance using these techniques may also be available through the National Geodetic Survey (NGS) Geodetic Services Division.

1.4.1.1.2 Partial Survey A partial vessel survey shall be conducted if minor changes have been made to the vessel configuration, but the most recent full survey has not been rendered obsolete. Partial surveys are typically appropriate when equipment is removed and replaced or repositioned on a vessel without disturbing the network of permanent benchmarks. In such cases, the new position of the instrument can be determined by surveying its position relative to the undisturbed benchmarks. The original survey shall then be updated and would remain valid. Partial surveys are significantly less time consuming than full surveys, but are only valid if benchmarks installed as part of the original survey remain undisturbed. When in doubt as to whether a new full survey is necessary or a partial survey is sufficient, field units shall complete a full survey of the vessel.

Partial surveys are basically identical to full surveys, but on a much smaller scale. The same rules and considerations described for full surveys apply to partial surveys. Since measurements are typically made over short distances and require few setups (assuming benchmarks have been installed near instrumentation as recommended), good accuracy can often be achieved with traditional survey methods. However, advanced methods may provide a more accurate estimate for measurement error.

1.4.1.1.3 Verification Survey Verification surveys are conducted to check the validity of pre-existing full (or combination of full and partial) surveys when no changes to the vessel's configuration have occurred. This is the minimum survey required as part of Annual Systems Preparation and, as such, shall be conducted at least annually. The purposes of a verification survey are to review the offsets, error estimates, and documentation of the prior survey, and to check for measurement blunders, vector algebra mistakes, sign errors, etc.

Verification surveys can be viewed as a "sanity check" of the existing survey data and may be conducted using traditional methods. Typical procedures consist of pulling steel tape between benchmarks to verify the offset values and rechecking the vector algebra to confirm established values. Error estimates in the original documentation shall be reviewed for consistency and suitability for the vessel's current mission. Any discrepancies discovered during a verification survey may trigger a partial survey or a new full survey of the vessel.

1.4.1.2 Periodic Quality Assurance Checks

Periodic quality assurance checks are simply Verification Surveys, or portions thereof, performed at the discretion of the field unit. This type of check would be used if the vessel was involved in an incident, such as a grounding, that might have altered the positions of benchmarks and instrumentation, affecting the validity of the annual survey. If changes are found, a partial survey or new full survey of the vessel may be necessary.

1.4.1.3 Documentation & Reporting Requirements

The documentation required for vessel static offset surveys varies with the extent of the survey conducted. Documentation, as defined below, for static offset surveys shall be maintained by the field unit and available for review during Hydrographic Systems Reviews and at the request of OCS. Copies of documentation for all full and partial surveys shall be transmitted to HSTP. The dates, basic methodology used, and responsible professional survey agency (if applicable) for vessel static offset surveys shall be entered in the Hydrographic Systems Inventory. Any interim survey performed as a quality assurance check shall be described in the DAPR for all associated projects.

1.4.1.3.1 Full and Partial Surveys Documentation for full and partial vessel offset surveys shall include the following:

- A full description of the equipment and technique employed, including diagrams showing the positions of setups and any pertinent technical data available for the instruments used for the survey. The survey location and description of how the vessel was leveled and immobilized, if applicable, should also be provided.
- Pictures and/or diagrams showing the general arrangement of the surveyed vessel and identifying the positions of benchmarks and instruments.
- An error analysis describing how the error values for each measurement were determined.
- Raw measurement data and a table of final results (including error estimates). A reviewer should be able to easily reconstruct the steps of data reduction from the information provided.
- A copy of Vessel Reports, generated in CARIS HIPS and SIPS Vessel Editor, for each resulting CARIS HIPS Vessel File (HVF).

1.4.1.3.2 Verification Surveys Documentation for verification of an existing full (or combination of full and partial) vessel offset survey shall include the following:

- A simple description of the equipment and techniques used for measurements.
- A reference to the full survey or combination of full and partial surveys that were verified.
- A copy of Vessel Reports, generated in CARIS HIPS and SIPS Vessel Editor, for each HVF which will remain in effect.
- Notation of any discrepancies discovered in the prior survey(s) and how these items were resolved.

1.4.2 Vessel Dynamic Offsets

Dynamic offsets are those parameters of a vessel that are expected to change over relatively short time periods. The primary dynamic offset is vessel draft. A hydrographic survey vessel's draft and, therefore, the vertical position of the sonar transducer within the water column is affected by many factors, including the vessel's loading, weight distribution, and speed through the water. When addressed as one vessel characteristic, these effects are referred to as "Dynamic Draft." Dynamic draft is the sum of "Static Draft" and "Settlement and Squat".

Static draft is the draft of the vessel at rest, fully loaded and outfitted for surveying. This value can be affected by the amount of equipment, fuel, personnel, and other gear loaded on the vessel, and is also a function of the density of the water in which the vessel is operating.

“Settlement” is the purely vertical component of this vessel characteristic and is measured at the vessel’s approximate center of motion. Although this vertical displacement is in the same direction as heave, settlement is usually filtered out of recorded heave data because its frequency is much lower than the cutoff frequency of high pass filters typically associated with heave measurement devices. As a result, settlement must be measured and corrected for independently of heave action.

”Squat” refers to the tendency of a vessel’s stern to sink into the water as speed increases while operating in displacement mode (i.e., not on a plane). Squat typically results in a bow-up attitude, although a reverse effect may actually take place at higher speeds for some hull designs. Since echosounders are generally not mounted directly at a vessel’s center of motion, squat acts on a lever arm from the center of motion to the echosounder, causing a vertical displacement of the transducer. On vessels equipped with attitude sensors, this effect is addressed as a part of attitude measurements and corrections. For vessels without attitude sensors, squat must be measured and corrected for as a part of dynamic draft.

1.4.2.1 Calibration Requirements and Methods

1.4.2.1.1 Static Draft As part of Annual Systems Preparation, static draft shall be measured across the anticipated range of loading and buoyancy conditions. At a minimum, field units should track changes in static draft for a sufficient period of time to develop a statistically significant sample of values from which an error estimate can be produced. Depending on these results and the requirements of the survey, the frequency of draft measurements and updates of the HVF necessary during survey operations will vary. On some vessels, it may be necessary to measure static draft as often as twice a day, while annual measurements may be sufficient for others. Factors influencing the frequency of static draft measurement include the following:

- Survey Accuracy Required - If the error associated with static draft measurement is determined to be acceptable for meeting survey accuracy requirements, a single static draft value may be sufficient. This value should be the mean of multiple observations taken over a wide range of loading and buoyancy conditions for the vessel. If survey accuracy requirements increase, more frequent static draft measurements may be necessary.
- Loading Conditions - Vessels with a wide range of loading configurations will require more frequent static draft measurements than vessels with minimal loading changes. For example, many NOAA ships conduct survey operations both with and without launches in the davits, which can create a significant difference in vessel draft. Likewise, a hydrographic survey launch’s static draft may vary noticeably with the amount of fuel loaded and the number of personnel embarked.
- Buoyancy - A vessel’s static draft will vary with the density of the water in which it floats. If the vessel will be operating in waters with a wide range of densities (most strongly influenced by salinity), more frequent observation of static draft may be necessary. Additionally, water density may change significantly with project area, making static draft determined at one location inappropriate for survey operations in another area.

1.4.2.1.1.1 Static Draft Measurement Techniques The technique chosen to measure static draft may be influenced by the anticipated frequency of measurement required. Examples of measurement techniques include the following: Draft Marks on Hull - During the static offset measurement survey (see 1.4.1) the vessel's hull can be marked with vertical elevation differences from the Vessel Reference Point. If this method is used, the hull should be marked on both the port and starboard sides, in the athwartships plane of the Vessel Reference Point. Static draft is then determined by averaging the port and starboard readings. Sight Tube - A more precise method for measuring static draft is a clear plastic or glass sight tube installed in the interior of the vessel. This method can be particularly useful on hydrographic survey launches. The lower end of the tube is connected to a through-hull fitting below the waterline (with a valve at the hull), and the top is either connected to a through-hull above the waterline or extends sufficiently high enough above the waterline to prevent flooding. The clear portion of the sight tube, where measurements will be read, should be installed directly over (or as close as possible to) the vessel RP and graduated for direct measurement of the waterline offset from the reference point. *Note: The static draft information is to be placed in the 'waterline' entry in the Caris HVF.*

1.4.2.1.2 Dynamic Draft At a minimum, dynamic draft shall be measured during Annual Systems Preparation. Although dynamic draft is a function of both hull shape and weight distribution, the influence of weight distribution is typically negligible. Thus, dyanmic draft can be measured annually with the vessel in an average loading configuration, and the results combined with a range of static draft measurements for a final dynamic draft determination. Vessels with ancillary trim capabilities (e.g., trim tabs, jet drives, and outboard motors) should establish operating procedures to standardize vessel trim during survey operations.

1.4.2.1.2.1 Dynamic Draft Measurement Techniques Settlement and squat are actually two separate parameters, but they can be easily measured together. If possible, this measurement should be accomplished in a body of water at least 7 times the vessel draft, where water level and current effects will be minimal for the period of the calibration. There are three common methods of determining dynamic draft values. Each method is described below.

Optical Level This technique uses an optical level to site the height of the vessel moving at different speeds through the water, relative to a fixed position ashore. The basic procedures are as follows:

- Set Up - Set up an optical level on shore near a channel or fairway where the vessel will be free to maneuver. The closer the level station is to where the vessel will traverse, the more accurate the readings will be. A pier is a valid location for the level station, but the pier must be a stable structure that does not exhibit significant movement over time. Level rods should be positioned on the port and starboard sides of the vessel. If the vessel to be calibrated is equipped with an attitude sensor, the level rods should be positioned in the athwartships plane of the vessel's approximate center of motion so that only settlement is measured (squat will be measured and corrected in conjunction with vessel attitude). If the vessel does not have an attitude sensor, the level rods should be located in the athwartships plane of the sonar transducer, which will combine squat effects in the measurement.
- Data Acquisition - Run the vessel in opposing directions (either perpendicular to or parallel with the level station line of sight) at various speeds, ranging from dead slow ahead to slightly faster than the maximum anticipated survey speed. On each run, the vessel must be allowed sufficient time to stabilize in attitude and speed prior to the measurement point. For each speed, a rod measurement should be taken on each side of the vessel. The port and starboard values for each speed are averaged to cancel the effect of any current or vessel list. Before and after each pair of runs, the elevation values for the vessel at

rest should be measured in order to correct for any change in water levels over the course of the test. The data should be recorded in tabular format, with the final dynamic draftt value for each speed being the difference between the average at rest readings (before and after each pair of runs) and the average of the port and starboard underway readings.

Real-Time Kinematic (RTK) GPS Procedures are currently being developed for a real-time kinematic GPS determination of dynamic draft. These methods have not yet been approved by OCS and shall not be used for Annual Systems Preparation.

Echosounder This technique uses a vessel's MBES system to determine dynamic draft. The basic procedure is described below, and a detailed Standard Operating Procedure (SOP) for this method is included in Appendix 1 (MBES_Settlement_and_Squat_SOP.doc).

- Data Acquisition -Data should be acquired in an area with a flat seafloor and relatively shallow water. Water depth should also be at least seven times the vessel draft to reduce attitude bias. The geographical location should be as close as possible to a water level station. If the survey time is planned to minimize currents, adequate data can typically be acquired by running in one common direction for all vessel speeds. If currents are significant, it will be necessary to acquire data in opposing directions for each speed and average the two values. As with the optical level method, vessel attitude and speed must be stable while acquiring data.
  - Line Acquisition -Plan a survey line approximately 1000 meters in length. Establish a center reference point for three approximately 20m^2 reference areas located at distances of ¼, ½, and ¾ along the line as shown in Figure 1.1. Acquire data along the line at various RPM intervals, ranging from the minimum to the maximum speed anticipated for survey operations. Minimize across-track error during line navigation and establish a constant speed and heading prior to logging data. Monitor and minimize induced heave during data acquisition.

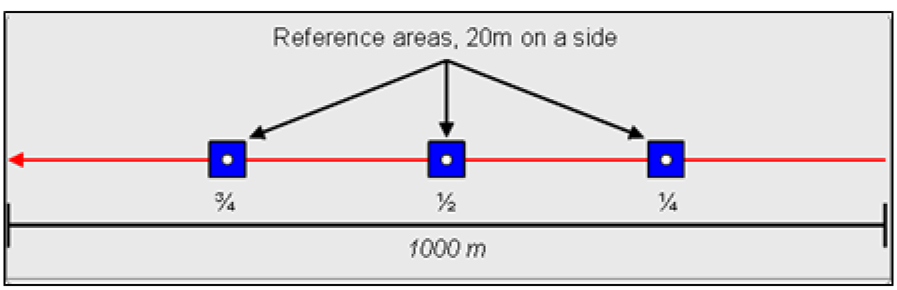

Figure 1.1: Recommended line plan for determining dynamic draft using a vessel's echosounder.

- Reference Area Acquisition - At each reference area, acquire data along the line at the lowest speed possible while maintaining heading and stable attitude to create a baseline with negligible dynamic draft. It is recommended that reference area data be acquired both before and after line acquisition to bracket and evaluate any significant water level variation. Compare these reference area depth measurements with each of the at-speed measurements to determine offsets caused by speed variation. Conduct a sound velocity cast near the center reference point.
- Data Processing Soundings -Filter soundings to reject all but those with the highest data quality flag. Sample all line and reference area soundings within each 20 m x 20 m area.

Minimally clean subsets for gross flyers and noise. Query all soundings from each subset and import these data to MS Excel as tab-delimited records. Sort the data by line number and calculate the median surface depth for each speed level at each reference area.

- Navigation/Speed - Query position fixes for individual lines within each reference area subset, and import these data into Excel as tab-delimited records. Calculate the average speed for each RPM in each of the reference areas.
- Offset Tables - For each reference area, subtract the median reference area depth from median depths for each RPM/speed interval to calculate relative dynamic draft offsets. Plot Speed vs. Offset for each of the 3 reference areas to evaluate data consistency. Average data from the ¼, ½ and ¾ point reference areas to calculate final dynamic draft values.
- Error Analysis -The standard deviation of each speed correction should be calculated by comparing the values derived from each of the three surface areas at that speed.

1.4.2.2 Periodic Quality Assurance Checks

Static draft shall be re-measured at whatever frequency determined necessary to meet survey specifications. However, at a minimum, static draft should be checked against previous survey values at the start of a new project and whenever a vessel will be conducting survey operations with an atypical loading configuration. Dynamic draft shall be re-measured if the vessel's hull shape is altered, significant changes in weight distribution of the vessel have been made, or other physical alterations have been made to the vessel that may affect dynamic draft values.

1.4.2.3 Documentation and Reporting Requirements

Dynamic offset measurement documentation shall be broken into two separate sections, one for Static Draft and one for dynamic draft measurements. All information listed below should be documented. This documentation shall be maintained by the field unit and available for review during Hydrographic Systems Reviews and at the request of OCS. The dates and basic methodology used to determine dynamic offset measurements shall be reported in the DAPR for each applicable project. The actual frequency of static draft measurements, any significant changes to static draft, and any subsequent changes to dynamic draft should also be included with this documentation.

Static draft measurement documentation shall include the following:

- A complete description of the procedure used to determine draft and estimate error.
- Geographical location where measurements were made and number of observations used for draft determination.
- Raw draft measurement data in tabular format and error estimate calculations.
- Final static draft values, as applied in the CARIS HVF.
- The frequency with which draft will be measured during subsequent survey operations, with justification for this decision.

Dynamic draft measurement documentation shall include the following:

- A complete description of the procedure used to determine dynamic draft, with a chartlet identifying the geographical area where measurements were made.

- ◦ Raw data with sufficient explanation of data reduction to enable recalculation of the final dynamic draft values and error estimates.
- ◦ Final dynamic draft values, as applied in the CARIS HVF.

Note: Think carefully about the sign of the dynamic draft values placed in the Draft sensor entry in the Caris HVF. Caris expects the change in Z to be a positive down, so a sinking of transducer creates a shallower depth than the “true depth”, and the dynamic draft value will be positive. If the vessel rises in the water, the measured depth will be deeper than the “true depth” and the dynamic draft value will be negative. Depth= Observed depth – Waterline + change in depth.

1.4.3 Wiring diagrams

All field units should maintain up-to-date wiring diagrams for each of their survey vessels. These wiring diagrams should be reviewed and updated during the Annual Systems Preparation process. An sample diagram is in the chapter 1 appendix.

1.5 Hardware Systems

Hardware systems used by NOAA field units for hydrographic survey operations range from technologically advanced echosounders and attitude sensors to simple lead lines. Regardless of technology or complexity, each instrument must be properly maintained and calibrated in order to provide quality data.

Calibration, maintenance, documentation, and reporting requirements established by OCS for common hardware systems used by NOAA hydrographic field units are described in sections 1.5.1-1.5.10. New sensors and instruments unique to only one or two field units may not be addressed in this manual. Likewise, as NOAA’s organizational expertise with existing systems continues to grow, new and improved procedures that supersede those documented here will be developed. In such cases, this section of the FPM shall be used as a guide for the development, implementation, and documentation of new procedures. If a new procedure is used, it must be approved by HSTP and documented with sufficient detail for the process to be recreated.

1.5.1 Position, Attitude, and Heading Sensors

For OCS hydrographic surveys, vessel position is typically determined using differentially corrected GPS data (DGPS). Attitude sensors are often employed to measure a vessel’s roll and pitch about its RP and any purely vertical heave action affecting the vessel. The vessel’s orientation about its vertical axis (i.e., yaw) is generally determined with a heading sensor or gyroscopic compass. Attitude and heading values measured by these sensors are typically applied to sounding data during post-processing. Each of the aforementioned sensors may be stand-alone systems, or they may be integrated into a navigation system that will collectively determine vessel position, attitude, and heading.

Note: Not all NOAA hydrographic field units may be outfitted with an attitude sensor. However, this equipment will be included on any NOAA vessel used to acquire multibeam echosounder data. Vessel attitude must be measured and applied to multibeam data to produce accurate soundings. Due to the wide beam angle of vertical beam echosounders, attitude corrections are less critical for this type of data. However, CARIS HIPS is capable of applying attitude data to VBES when available.

The Applanix POS/MV (Position and Orientation System/Motor Vessel), a GPS-aided inertial navigation system, is the most common system used by NOAA hydrographic field units to measure vessel position, attitude, and heading. As such, the POS/MV calibration and reporting requirements are specifically addressed in this manual. Field units equipped with alternate position, attitude, or heading sensors shall contact the regional HSTP Field Support Liaison to develop approved calibration and maintenance requirements.

1.5.1.1 Applanix POS/MV

The POS/MV navigation system will calculate survey-quality vessel position, heading, and attitude data. Primary system components consist of a processing unit, two GPS antennas, and an inertial measurement unit (IMU), which is typically installed at the vessel's RP for NOAA configurations.

1.5.1.1.1 Calibration Requirements and Methods At a minimum, NOAA hydrographic field units shall calibrate the POS/MV during Annual Systems Preparation. Additionally, the POS/MV shall be recalibrated after any IMU or antenna installations, movements, and/or modifications. The appropriate POS/MV Installation and Operation Guide will contain comprehensive guidance on system operation and calibration.

Note: Although the POS/MV Installation and Operation Guide refers to the calibration process as "antenna installation calibration," it should be performed following any physical antenna or IMU adjustments, not just antenna installation. Additionally, all IMUs shall be turned in to the regional EED depot every three years so that the units can be shipped to Applanix for factory service and recertification. If a field unit has been equipped with a Version 4 or higher POS/MV system, it is possible to perform an additional lever-arm calibration. However, this calibration should not be attempted without appropriate RTK support. Field units should contact the regional HSTP Field Support Liaison for RTK support prior to conducting a lever-arm calibration.

1.5.1.1.1.1 Offsets & Reference Frame Conventions Prior to calibration, POS/MV lever arm distances should be entered, as necessary, and/or verified in the POS/MV controller software. Be very careful not to enter values for offsets that will be applied to data during post-processing via the HVF. If the IMU is collocated with the vessel's RP and CM, the distance from the IMU to the primary GPS antenna (port side for OCS configurations) and the distance between GPS antennas may be the only offsets that need to be entered in the POS/MV controller software. Measured antenna separation distance must be accurate to within 5 mm, per the manufacturer's specifications. Refer to the POS/MV Installation and Operation Guide for additional measurement accuracy requirements and coordinate system conventions. Note: Be certain that offsets entered in the POS/MV controller software correspond to the local POS/MV coordinate system, which may differ from the vessel reference frame coordinate system. A summary of coordinate systems for common OCS systems and software is included in Appendix 1 (Coordinate_Systems.pdf).

1.5.1.1.1.2 Performing the Calibration Detailed instructions for performing a POS/MV calibration should be reviewed in the POS/MV Installation and Operation Guide. For a successful calibration, the POS/MV GPS Azimuth Measurement Subsystem (GAMS) must have data available from 7 or more satellites and a Positional Dilution of Precision (PDOP) equal to or less than 3.0. The calibration should be performed at a time when satellite geometry is good. GPS mission planning software can be used to identify an optimal calibration time, during which the PDOP will be at a minimum. Mission planning software is included on the Hydrosoft DVD (provided annually to field units by HSTP) and also available at no charge from Trimble at www.trimble.com/planningsoftware.html.

The POS/MV calibration should be performed in an open area where unrestricted maneuvering is possible and there are few vertical features likely to produce multipath signals. Set the user multipath setting to “Low” to allow the system to calibrate with the highest accuracy. It is important for heading accuracy to settle to less than the threshold set under the GAMS Installation Parameters before performing a calibration.

Note: This threshold shall always be set to 0.5 degrees or less when calibrating systems for OCS survey operations. Maneuvering the vessel in a figure eight pattern will help bring the heading accuracy within this range. Once a calibration is started, it often takes more than the 1-2 minutes on a straight course stated in the POS/MV Installation and Operation Guide for the “CAL in Progress” process to complete. After a successful calibration, save the new calibration values into non-volatile memory as described in the POS/MV Installation and Operation Guide, and save a copy of the final POS/MV configuration file for reference.

1.5.1.1.2 Periodic Quality Assurance Checks Once a high-quality POS/MV calibration has been performed, it should remain valid until system components are moved or altered. The POS/MV should operate reliably provided adequate satellite coverage and differential correctors are available. If the POS/MV becomes problematic, recalibration may be conducted at the discretion of the field unit. If a recalibration is desired, the same process used for the annual calibration should be repeated.

Note: If the POS/MV is recalibrated, a new patch test should be performed for any associated multibeam echosounder systems.

1.5.1.1.3 Documentation and Reporting Requirements For each calibration conducted, system settings, procedures, and results achieved should be recorded in a POS/MV Calibration Report. A blank report form is included in Appendix 1 (POS-MV_Cal_Report.xls), with sample data entered in red font. This documentation shall be maintained by the field unit and available for review during Hydrographic Systems Reviews and at the request of OCS. The dates of current POS/MV calibrations shall be reported in the Hydrographic Systems Inventory. All POS/MV calibrations conducted shall be described in the DAPR for each applicable project.

1.5.2 Sound Speed Measurement Instruments

Accurate measurements of sound speed (often referred to as “sound velocity”) both through the water column and at the water’s surface are critical to hydrography, particularly if soundings are acquired using a multibeam echosounder. Two basic types of sound speed instruments are currently used by NOAA hydrographic field units, those which directly measure sound speed (commonly referred to as “velocimeters”) and those which measure conductivity, temperature and depth and then calculate sound speed (commonly referred to as “CTDs”). All field units performing OCS surveys shall proactively monitor the accuracy of sound speed measuring instruments and conduct preventative maintenance as described below.

1.5.2.1 Calibration Requirements and Methods

All sound speed measuring instruments employed by NOAA hydrographic field units shall be annually calibrated and inspected by the manufacturer, unless the manufacturer recommends a different time period. Field units should turn in all sound speed measuring instruments to the regional EED depot promptly after arriving for winter inport or during another suitable period of inactivity. EED will arrange for the instruments to be returned to the manufacturer for calibration and inspection. This process takes approximately six weeks.

Note: For DigibarPro systems, only the probe needs to be returned for annual calibration. There is no need to remove the cable or display unit from the vessel unless these components require repair or replacement.

Field units that can not feasibly submit sound speed measuring instruments to the regional EED depot shall contact EED to coordinate a direct submission to the manufacturer. Following annual calibrations, comparisons equivalent to the Data Quality Assurance processes described in section 1.5.2.2 shall be conducted for all sound speed measuring instruments.

1.5.2.2 Periodic Quality Assurance Checks

Periodic quality assurance checks shall be performed for all sound speed measuring instruments. NOAA hydrographic platforms shall conduct these quality assurance checks on a daily or weekly basis as described below. Field units with sound speed measurement instruments not addressed in this manual should contact the regional HSTP Field Support Liaison to develop a comparable quality assurance plan.

1.5.2.2.1 Daily Data Quality Assurance (Daily DQA) If the vessel is equipped with a surface sound speed measuring instrument (typically installed at the head of a multibeam sonar), compare a measurement from this instrument to the results of a full sound speed profile acquired at the beginning of each day the surface instrument will be used. This comparison can be performed in NOAA's Velocwin software using the “Surface Sound Speed DQA” function. All discrepancies greater than 1 m/s should be noted and tracked to determine if the instrument requires repairs or recalibration. Note: NOAA hydrographic field units have experienced several failures with this type of instrument. Since surface sound speed data is critical for acquiring data with flat-faced MBES systems, these instruments must be monitored and tested each day prior to operations.

1.5.2.2.2 Weekly Data Quality Assurance (Weekly DQA) A full water column profile from each sound speed profiling instrument shall be compared to an independent source at least once during each week of survey operations. This comparison should be accomplished by conducting a simultaneous cast with two profiling instruments and comparing the results using Velocwin's “Compare Two Profiles” function. Caution: If simultaneous casts are processed in Velocwin using the same vessel name, the processed file names will be identical and one will be overwritten. The user should rename the first file processed to avoid this potential problem. Data from two different types of profilers can be used for this comparison, provided both datasets have been initially processed in Velocwin. Comparison casts should be conducted in water at least as deep as typical depths for the current project. Note: If a Digibar is to be used for a simultaneous cast, first conduct a Velocwin “Digibar DQA” comparison for the instrument using a fresh water sample.

1.5.2.3 General Maintenance Practices

Velocimeters and CTDs should be rinsed with freshwater at the end of the day after use. The moving parts of the winch on the Moving Vessel Profiler (MVP) system requires weekly lubrication of its moving parts (e.g. gears and levelwind) to maintain effectiveness and to sustain its lifetime. It is also highly recommended to shift the messenger on the MVP every 24 hours of continuous use however armoring may make this more tedious. Field units should routinely do an inspection of the MVP towfish. For more information regarding possible issues with the MVP system see 'Towed sensor issues and practices.ppt' in the Chapter 1 Appendices.

1.5.2.4 Documentation and Reporting Requirements

Results from annual sound speed instrument calibrations, i.e., manufacturer's documentation and the corresponding digital calibration coefficient file, shall be maintained by the field unit and available for review during Hydrographic Systems Reviews or at the request of OCS. The dates of annual calibrations and any instrument problems or non-routine maintenance performed shall be reported in the Hydrographic Systems Inventory.

If using Velocwin, the results of each DQA test performed will be sorted by project number and saved to a file named <project number>.DQA, (e.g., OPR-A###-AA-YY.DQA) in the "SVfiles" directory. If Velocwin is not used for weekly data quality assessments, these comparisons shall be manually recorded. DQA records associated with each survey shall be included in Separates II of the Descriptive Report. Documentation for all calibrations or maintenance conducted shall be included in the DAPR for each applicable project.

1.5.3 Manual Depth Measurement Equipment

Although no longer used as a primary means of survey, lead lines and sounding poles are invaluable for some operations. These tools can be used to take soundings in areas too shallow for echosounders or to verify least depths over dangers to navigation or shoals. The most common use of lead lines is as a calibration standard for echosounders. However, like all measuring devices, these tools have their own calibration requirements. Both lead line and sounding pole requirements are addressed in this section.

1.5.3.1 Calibration Requirements and Methods

1.5.3.1.1 Lead Lines All field units engaged in hydrographic surveys where general depths are less than 40 meters shall carry one or more marked and calibrated lead lines. Depending on the depths in which they will be used and the size of the vessel, OCS recommends that lead lines are 30m to 60m long. Each lead line shall be marked with a numerical identifier to be retained throughout the life of the lead line or until re-marking is necessary.

Traditional lead line material is mahogany-colored tiller rope with a phosphor-bronze wire center. Specifications for this material and directions for making and maintaining a traditional lead line can be found in Appendix 1 (Leadline_Sndngpole_Directions.pdf). Since line and tape materials have evolved significantly and lead lines are now used in special circumstances, rather than for entire surveys, it may be appropriate for alternate materials to be used when constructing a lead line. When choosing a lead line material, key properties to be considered are strength and elasticity. The line or tape must not part if deployed from a vessel underway and must not stretch significantly under tension or when wet.

All lead lines used for OCS hydrographic surveys shall be graduated to at least the decimeter level. Any convenient system of marking that will minimize reading errors may be used, provided each whole meter of line is marked and identified with a clearly written numerical depth value.

Lead lines shall be calibrated by comparison with a known standard during Annual Systems Preparation and prior to each day's use if constructed with non-traditional material. The testing standard should be a survey quality metal tape, pre-measured graduation marks on deck or ashore, or similar item. If the mean correction exceeds 0.1 m the lead line must be re-marked.

1.5.3.1.2 Sounding Poles When surveying in depths too shallow for an echosounder, it may be prudent to use a sounding pole if the area is flat and the waters are protected. Sounding poles shall not be used in depths greater than 4 meters and are typically not used in depths greater than 2 meters.

A traditional sounding pole is made from a meter length of 1.5 inch (3.81 cm) round lumber capped with a weighted metal shoe at each end to hasten sinking. Shorter poles may be used, depending on the depth conditions. Directions for making and maintaining a traditional sounding pole can be found in Appendix 1 (Leadline_Sndngpole_Directions.pdf). Since modern pole, pipe, and stick materials are readily available and sounding poles are now used in special circumstances, rather than for entire surveys, it may be appropriate for alternate materials to be used when constructing a sounding pole. When choosing a sounding pole material, key properties to be considered are strength, weight, and bluntness. The pole must not significantly bend if deployed from a vessel underway or weaken when wet. Additionally, it must not be so buoyant or sink so rapidly that it becomes difficult to handle and must not penetrate the seafloor to an extent that would generate erroneous soundings.

All sounding poles used for OCS hydrographic surveys shall be graduated in meters to at least the decimeter level. Any convenient system of marking that will minimize reading errors may be used.

Any sounding pole maintained aboard a NOAA hydrographic vessel shall be calibrated during Annual Systems Preparation. Calibration shall be against a known standard, such as a survey quality metal tape, to ensure that depth markings are unambiguous and accurate. Sounding poles created between Annual Systems Preparation events shall be calibrated prior to use on an OCS hydrographic survey.

1.5.3.2 Periodic Quality Assurance Checks

Due to the static nature and infrequent use of manual depth measurement equipment, there are no requirements for accuracy checks, other than annual calibrations, if traditional lead lines or a regularly maintained sounding pole is being used. As previously stated, lead lines constructed with non-traditional material shall be calibrated prior to each day's use, and sounding poles created on-the-fly for special circumstances encountered shall be calibrated prior to use on any OCS hydrographic survey.

1.5.3.3 Documentation and Reporting Requirements

A Lead Line and Sounding Pole Calibration Report shall be completed each time a lead line or sounding pole is made or compared to a standard. A report form is provided in Appendix 1 (Leadline_SndngPole_Cal_Report.xls), with sample data in red font. Reports for calibrations conducted during Annual Systems Preparation shall be maintained by the field unit and available for review during Hydrographic Systems Reviews and at the request of OCS. The dates of current calibrations shall be reported in the Hydrographic Systems Inventory. Documentation for calibrations shall be included in the DAPR for each applicable project.

In addition to the above reporting requirements, a full Sounding System Comparison shall be completed each year as a part of Annual Systems Preparation, following calibration of all sounding systems. A lead line shall be used to manually acquire a standard for comparison to calculated depths from each of the field unit's vertical beam echosounders, multibeam echosounders, and diver least depth gauges. This process shall be documented using the form provided in Appendix 1 (Sndng_Sys_Comparison_Log.xls) and included in the DAPR for each applicable project.

1.5.4 Vertical Beam Echosounder (VBES) Systems

NOAA hydrographic field units may use VBES systems for water depth measurement and/or to confirm depths measured by other systems, such as multibeam echosounders. The consistency and accuracy of VBES soundings are directly related to the care with which these instruments are calibrated, maintained, and operated. It is critical that field units both ensure these systems are properly calibrated and educate operators about the effects of manually adjusting the transceiver controls such as power, gain, and sensitivity.

Vertical beam echosounders are typically either dual frequency or single frequency. Users should operate each echosounder in accordance with its manufacturer's documentation. When used for OCS hydrographic surveys, VBES systems shall be set with an assumed speed of sound through water of 1500 m/s. Recorded sounding data shall be corrected for actual sound speed, determined with a sound speed profiling instrument, during data post-processing.

1.5.4.1 Calibration Requirements and Methods

The field unit shall verify, during Annual Systems Preparation, that VBES sounding data are accurate and that each system is in proper working order. While a lead line comparison is the minimum VBES calibration requirement, a simultaneous comparison of lead line, VBES, multibeam echosounder, and diver least depth gauge data is also required by OCS during Annual Systems Preparation. (Refer to 1.5.3.3 for details on Sounding System Comparison.) If the VBES unit is found to be out of calibration, it should be sent to the regional EED depot, which will return it to the manufacturer for repair. Field units that can not feasibly submit VBES systems to the regional EED depot shall contact EED to coordinate a direct submission to the manufacturer.

When performing sounding system comparisons, the vessel should, ideally, be anchored in an area with a flat sandy bottom and calm sea conditions. If comparisons will also be made to DLDG data, the water depth should be between 10 and 20 meters. The lead line depth should be measured from a location close to the transducer and timed as near as possible to slack water to minimize any effect from current on the lead line. If the vessel has a known list or is large enough that a level platform can not be accurately determined, simultaneous lead line readings should be taken from each side of the vessel and averaged.

1.5.4.2 Periodic Quality Assurance Checks

For modern digital VBES systems, instrument errors are generally small, fixed in magnitude, and independent observed depths. However, to ensure that echosounders continue to operate properly, periodic confidence checks should be conducted. A confidence check can be accomplished by comparing VBES soundings to lead line readings, nadir multibeam echosounder depths, or DLDG data. As when performing a calibration, routine comparisons should be conducted in an area with a relatively flat and hard bottom, when sea conditions are calm.

Confidence checks shall be conducted at least once per week for all surveys performed with VBES systems. Any discrepancies identified between sounding systems that are greater than the allowable depth error for the corresponding survey must be investigated to determine if the equipment is in need of repairs.

1.5.4.3 Documentation and Reporting Requirements

Results of VBES calibrations and confidence checks shall be recorded in a Sounding System Comparison Log to be maintained by the field unit. A comparison log is included in Appendix 1 (Sounding_Systems_Comparison.xls) with sample data in red font. Calibration records for each VBES used for hydrographic surveying shall be available for review during Hydrographic Systems Reviews and at the request of OCS. Sounding System Comparison Logs shall be included in the DAPR for all applicable surveys.

1.5.5 Multibeam Echosounder (MBES) Systems

NOAA's hydrographic survey units use MBES systems to acquire full- and partial- bottom bathymetric coverage throughout a survey area, to determine least depths over critical items such as wrecks, obstructions, and dangers-to-navigation, and for general object detection. Field personnel should refer to section 5.1.2 of the HSSD.

Since MBESs are typically hard-mounted, high-resolution systems, soundings can be very accurately geo-referenced. Proper calibration of MBES systems is critical for maintaining this high level of accuracy and meeting OCS hydrographic survey specifications. Various models of swath-type multibeam sonars are used for NOAA hydrographic survey operations. For the purposes of this document these MBES systems will be treated as equivalent units unless otherwise specified.

1.5.5.1 Calibration Requirements and Methods

MBES performance is largely a function of the original system specifications. To ensure that MBES systems used for OCS surveys continue to perform adequately, all systems should be maintained and serviced in accordance with manufacturers specifications.

1.5.5.1.1 Offset Measurement and Verification Offsets for MBES systems shall be measured and/or verified as part of the vessel static offsets survey described in 1.4.1. OCS typically uses two types of MBES configurations, hull-mounted and pole- or lever-mounted. Particular attention must be paid to the alignment of the sonar head with respect to the keel of the survey vessel, as a very small alignment error can introduce significant positioning errors in the data.

In addition to the above alignment considerations, pole- and lever-mounted systems introduce another potential source of positioning error. Since these systems are deployed and retrieved after each use, care must be taken to insure that the sonar is both stabilized during use (via pins, guy wires, or the like) and that its deployed position does not vary. Stabilizing mechanisms should be inspected regularly for wear, stretching or general deterioration that could affect the sonar offsets or stability.

1.5.5.1.2 MBES Calibration As part of Annual Systems Preparation, field parties shall conduct a system calibration to quantify the accuracy, precision, and alignment for each MBES system. At a minimum, the calibration shall include determination of residual biases in roll, pitch, heading, and navigation timing error. This procedure, commonly referred to as a "patch test", is performed by acquiring data that will highlight only one bias parameter at a time. The patch test should be conducted in accordance with section 5.1.4.1 of the HSSD. This process is also described, in detail, in the MS PowerPoint presentation Multibeam_System_Calibration.ppt included in Appendix 1.

Generally two lines of data must be acquired to resolve each bias. Vessel speed, direction and/or seafloor slope will be specified for each line. Figure 1.2 illustrates the most efficient line plan for conducting a patch test; however, lines for each bias may be completed in separate areas if an ideal geographical location is unavailable. Once patch test data has been acquired, system integration errors are determined by aligning slopes and targets acquired from different directions and speeds.

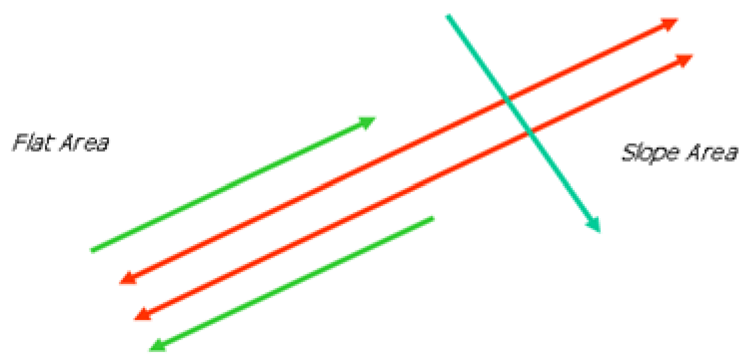

Figure 1.2: Most efficient line plan for MBES calibration testing.

If a MBES system has been configured with Precise Timing (see section 3.1.4.2), the hydrographer must determine the latency of the $UTC serial timing string that synchronizes the ISIS and Reson sonar clocks to the POS/MV. This procedure differs from the traditional methods for determining navigation time latency, as described in detail in section V of 'Upgrading NOAA Multibeam Acquisition Systems to "Precise Timing".' This document has been included in Appendix 3 (Precise_Timing_Setup.doc) and provides detailed procedures for configuring a MBES system with Precise Timing.

Once bias correctors are determined for a system, the appropriate values should be entered into the CARIS HVF for the corresponding vessel. If problems become apparent in the data or any part of the echosounder system configuration is changed or damaged, a new system calibration must be conducted.

1.5.5.2 Periodic Quality Assurance Checks

In accordance with section 5.1.4.1 of the HSSD, MBES confidence checks shall be performed at least once during each survey conducted by multiple vessels that acquire overlapping data. Surveys conducted with only a single vessel, shall perform confidence checks at least once per week. A confidence check can be accomplished by comparing nadir MBES values to lead line readings, VBES depths, or DLDG data. These comparisons should be conducted in an area with a relatively flat and hard bottom, when sea conditions are calm. Any discrepancies identified between sounding systems that are greater than the allowable depth error for the corresponding survey must be investigated to determine if the equipment is in need of repairs.

1.5.5.3 Documentation and Reporting Requirements

Each patch test conducted shall be documented in a MBES Calibration Table. A copy of this table is provided in Appendix 1 (MBES_Cal_Table.xls) with sample data entered in red font. In addition to a MBES Calibration Table, a chartlet showing the test area and line plan, with line numbers and headings clearly identified, shall be created for each system tested. The exact format of these chartlets is left to the discretion of the hydrographer. Calibration information shall be maintained by the field unit and available for review during Hydrographic Systems Reviews and at the request of OCS. Copies of patch test documentation shall be submitted with the DAPR for each applicable project.

Results of each MBES confidence check shall be recorded in a Sounding System Comparison Log to be maintained by the field unit. A comparison log is included in Appendix 1 (Sounding_Systems_Comparison.xls,) with sample data in red font. Sounding System Comparison Logs shall be included in DAPR for all applicable projects.

1.5.6 Diver Least Depth Gauge (DLDG)

The DLDG is a portable, self-contained, diver-deployed instrument that measures pressure in absolute pounds per square inch (PSIA). The gauge consists of an electronic pressure sensor, LED readout, and rechargeable batteries housed in a water and pressure resistant enclosure (see Figure 1.3). Least depth values are computed from the difference between surface pressure (pre-dive) and the pressure observed by the diver at a feature's least depth.

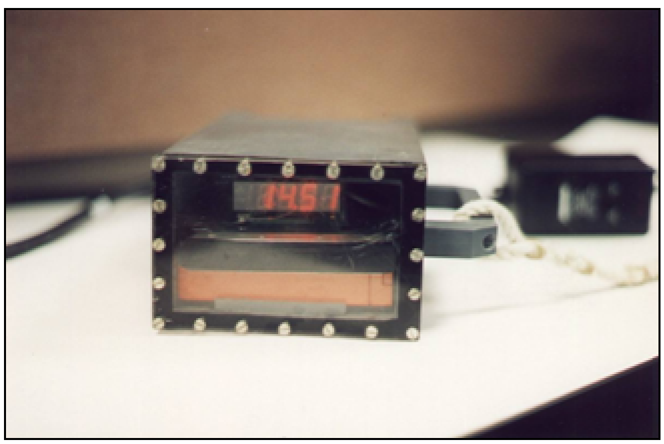

Figure 1.3: Front view of a diver least depth gauge model III.

1.5.6.1 Calibration Requirements and Methods

Each DLDG used for OCS hydrographic surveys shall be calibrated annually. These instruments should be submitted to the regional EED depot promptly after arriving for winter inport or during another suitable period of inactivity. EED will arrange for the instruments to be returned to the manufacturer for calibration and inspection. Field units that can not feasibly submit DLDGs to the regional EED depot shall contact EED to coordinate a direct submission to the manufacturer.

Once the DLDG calibration report has been received, a copy must be forwarded to HSTP. HSTP personnel will generate, and provide to the field unit, a digital corrector file that must be loaded into Velocwin software to facilitate DLDG pressure data processing. After calibration, a

Sounding System Comparison including depths computed using the DLDG shall be performed and recorded using the form provided in Appendix 1 (Sndng_Sys_Comparison_Log.xls).

1.5.6.2 Periodic Quality Assurance Checks

Velocwin software includes a DLDG DQA utility, which compares the DLDG pressure measurement in air to barometric pressure. This comparison routine should be performed daily to record a relationship between the vessel's barometer and the DLDG. The DLDG DQA should also be performed before and after each day's dive operations to provide a pre-dive and post-dive record. If inconsistencies between the barometer and calculated DLDG pressure become apparent, the DLDG may require repair or recalibration. The DLDG DQA routine in Velocwin generates a graphic display of the DLDG pressure with respect to acceptable error margins. The test passes if the new DLDG data point (red dot) lies within the two dashed lines representing the acceptable error boundaries, as shown in Figure 1.4. Prior Daily DQA results are also displayed on this graph for comparison. Each time a Daily DQA is performed, the data are appended to a digital file DIVERDAILYDQA.DAT.

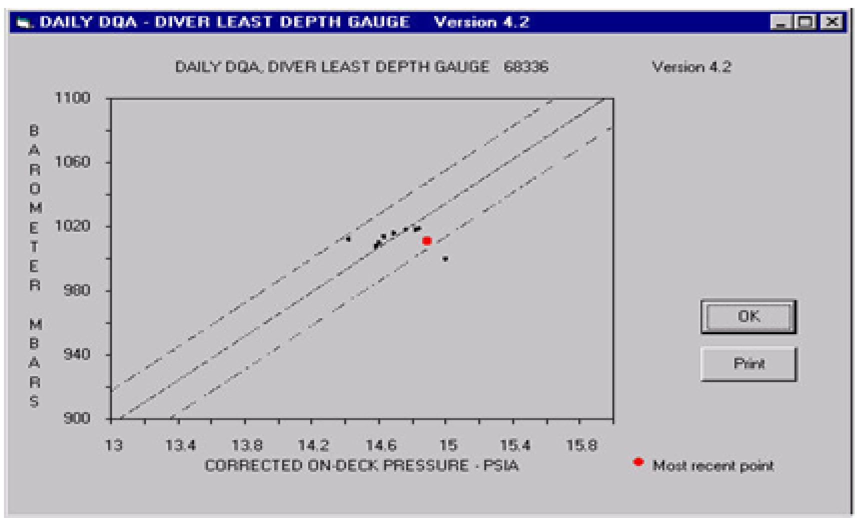

Figure 1.4: Velocwin DLDG daily DQA screenshot.

1.5.6.3 Documentation and Reporting Requirements

The manufacturer's DLDG calibration report, HSTP generated digital corrector file, and results of the post-calibration Sounding System Comparison shall be maintained by the field unit and available for review during annual Hydrographic Systems Review and at the request of OCS. The DAILYDQA.DAT file and reports for any additional Sounding System Comparisons shall be included in the DAPR for each applicable project.

1.5.7 Side Scan Sonar (SSS) Systems

NOAA hydrographic survey units use side scan sonar systems for both object detection and object recognition. Side scan sonar is typically used in conjunction with a VBES or MBES system to meet object detection coverage specifications for OCS surveys. Any SSS system used for OCS hydrography must be capable of detecting an object on the sea floor with minimum dimensions of 1 m x 1 m x 1 m, as stated in section 6.2.1 of the HSSD.

OCS uses both hull mounted and towed SSS system configurations. Horizontal accuracy for SSS operations will depend on the system configuration, investigation technique, water depth, and target density. However, the position of targets identified with side scan imagery must be sufficiently accurate to relocate the item for least depth and survey position determinations, usually via a MBES system. In general, side scan imagery should be capable of positioning point features to an absolute accuracy of less than 10 meters. NOAA field units use various models of side scan sonar for hydrographic survey operations. For the purposes of this document, these systems will be treated as equivalent unless otherwise specified.

1.5.7.1 Calibration Requirements and Methods

Side scan sonar object detection and classification performance is largely a function of the original system specifications. To ensure that side scan sonar systems used for OCS surveys continue to perform adequately, hydrographers shall return all side scan systems to the regional EED depot for annual inspection and maintenance. If a towfish is equipped with a pressure sensor, this must be serviced and calibrated as part of the EED annual maintenance. If a towfish has been equipped with a transponder for locating the system if lost, new lithium batteries shall be installed and the system tested using an interrogator as part of annual maintenance.

1.5.7.1.1 Offset Measurement and Verification Side scan system offsets must be measured and/or verified prior to performing a calibration. Depending upon whether the sonar configuration is hull-mounted or towed, requirements for offset measurements will vary. Offset requirements for each type of configuration are described below.

1.5.7.1.1.1 Hull-Mounted SSS Configuration For hull-mounted configurations, the phase center of the side scan shall be precisely positioned during the vessel static offsets survey. The phase center of the towfish is considered to be at the fore and aft midpoint of the transducers and on the centerline in the athwartships and vertical axes.

When hull-mounting a SSS, particular attention must be paid to the alignment of the towfish with respect to the keel of the survey vessel, as a very small alignment error can introduce significant positioning errors in the data. For example, a heading alignment error of only 1° will add 1.75 m horizontal positioning error at the edge of the swath on a 100-m range scale. In extreme cases, it may be necessary to measure alignment error with a yaw patch test, and enter a correction in the HVF. The field unit should contact the regional HSTP Field Support Liaison for assistance with this test, if needed.

1.5.7.1.1.2 Towed SSS Configuration For towed SSS operations, static vessel offsets should be measured to the towpoint. The actual towfish position is typically calculated using towfish depth and cable out measurements. Towfish depth may be determined by a depth sensor installed in the towfish or calculated by subtracting the towfish height (determined by a separate echosounder installed in the towfish or the first return of each sonar ping) from the depth of water (determined from a vessel echosounder). If a SSS is equipped with a pressure sensor, its accuracy should be tested annually and whenever the horizontal positioning accuracy of side scan targets is in doubt. Cable out can be estimated visually from calibrated markings on the cable or measured with an electronic cable counter. Each configuration is described below.

Note: When measuring cable out, the cable zero mark is not at its connection to the towfish, but at the phase center of the sonar.

- Marked Cable - Marked tow cables shall be measured using a survey grade metal tape and clearly marked. Cable markings shall be in meters and enable visual interpolation to a tenth of a meter. Since a cable jacket can stretch and slide over the conductors during use, cable measurement markings shall be verified annually, and whenever the hydrographer believes they may be in error.

- Cable Counter - Electronic cable counters shall be configured according to the manufacturer's instructions. The hydrographer shall verify the accuracy of the cable counter by comparing manual and electronic cable measurements at a range of cable lengths. This check shall be conducted annually, whenever the counter, cable, or sheave configuration is changed, and whenever the hydrographer believes there may be a cable measurement error. Note: For some cable counters, the serial data output being logged may be in different units than what is shown on the cable counter display. In such cases, the hydrographer may need to perform a conversion on raw cable out data either prior to logging or during post-processing.

1.5.7.1.2 SSS Calibration As part of Annual Systems Preparation, the field unit shall demonstrate that all side scan sonar systems to be used for OCS hydrographic surveys are capable of meeting object detection standards set forth in section 6.2 of the HSSD. An operational SSS Calibration Test shall be conducted to demonstrate the system's ability to detect and accurately position seafloor targets across the system's range on both sonar channels. Test information shall be recorded in a SSS Calibration Table. This table is provided in Appendix 1 (SSS_Cal_Table.xls) with sample data entered in red font.

The SSS Calibration test shall consist of a minimum of 10 side scan passes on a target approximately 1 m x 1 m x 1 m. The target shall be imaged from a variety of ranges and directions, with survey speed, water depth, and weather representative of typical survey conditions. Although dedicated test targets can be used for this check, targets of opportunity, such as buoy blocks, lobster pots, and appropriately sized rocks, may be sufficient. The hydrographer should use alternate systems (e.g., MBES) to determine a high accuracy absolute position of the target for comparison with SSS detected positions.

Figure 1.5 shows the OCS recommended line plan for conducting a SSS Calibration Test. Note that this line plan balances ensonifications on the port and starboard channels, across the range scale, from different target aspects, and from different directions. This approach assists the hydrographer in differentiating systematic and random errors in detection and positioning.

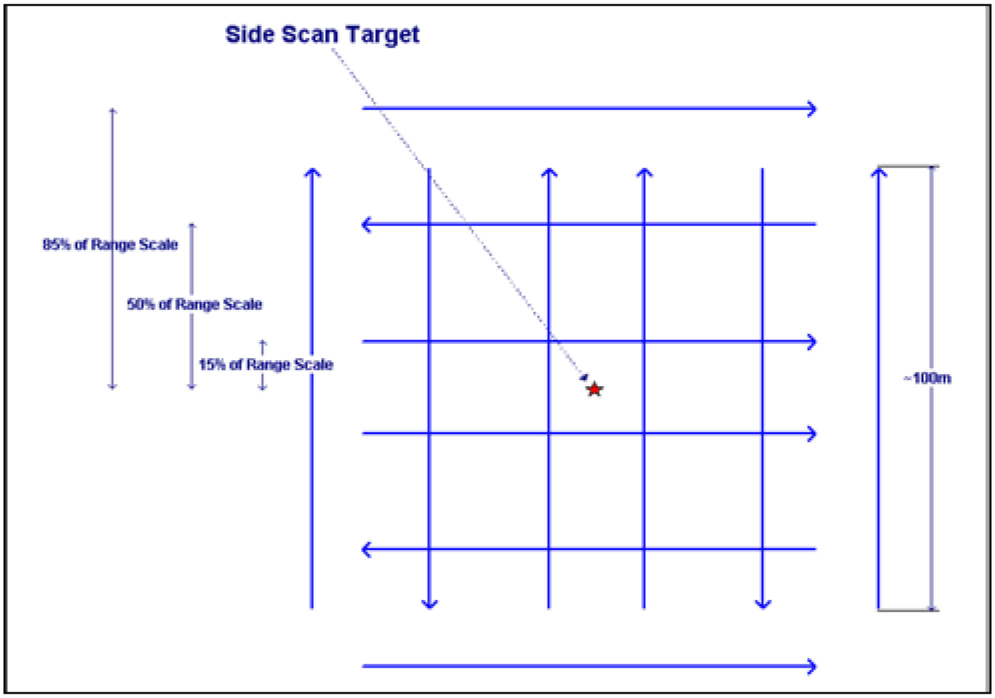

Figure 1.5: Recommended line plan for SSS calibration testing.

Test data shall be processed according to standard OCS hydrographic survey procedures and evaluated to identify any systematic problems with the sonar or vessel offsets. If the contact is not detected in at least nine of the 10 passes, the SSS towfish should be carefully inspected for damage and the system re-tested. If detection remains problematic, the field unit shall contact EED and the regional HSTP Field Support Liaison for guidance.

Successful object detections shall be used to compare the mean detected position with the absolute target position and to compute the approximate 95% Confidence Radius for the system. This radius should not exceed 5 meters for hull-mounted systems and 10 meters for towed systems. Several methods can be used to estimate the 95% Confidence Radius. A simple option is to plot the detected target positions in MapInfo, and use the "Compute Statistics" function to compute the sample standard deviation of the x and y components of the detection positions (computing statistics of the Eastings and Northings yields values in meters). Assuming a normal distribution, 95% of the samples will fall within 1.96 standard deviations of the mean. If the distribution of detections is similar in x and y, the 95% Confidence Radius is roughly 1.96 times the square root of the sum of the squares of the standard deviation of detected positions in x and y: $95\%\, confidence\, radius \approx 1.96\sqrt{\sigma_x^2 + \sigma_y^2}$

If the distributions in x and y are not similar, it is likely that a systematic bias exists that was not canceled by ensonifying the target from multiple ranges and directions.

Similar results can be obtained by measuring the error for each detection (the distance from the absolute target position to the detected position) and computing the sample mean and standard deviation of the errors. The approximate 95% Confidence Radius is then the sample mean plus 1.96 times the standard deviation.

1.5.7.2 Periodic Quality Assurance Checks

At least one confidence check of a SSS system shall be conducted each day the system is used for data acquisition. These checks should be in accordance with section 6.3.1 of the HSSD and consist of detecting a discrete object at the outer range scale limits for each sonar channel (i.e., port and starboard). Confidence checks shall be annotated in the daily data acquisition records. If these confidence checks repeatedly show discrepancies with expected performance, a new System Calibration may need to be performed.

Before surveying with a SSS system that has been either reconfigured or in storage, a “rub test” should be performed. The rub test is a simple procedure wherein a hydrographer observes the SSS trace while an assistant physically rubs one transducer on the towfish and then the other while the system is pinging. As the assistant rubs the transducer, the hydrographer should see a return on the corresponding channel of the imagery. A rub test failure can indicate system errors such as incorrect gain or power settings, a faulty cable, or damaged transducers. This test should be conducted while the towfish is out of the water and dry, to avoid the possibility of electric shock.

Caution: Do not leave a SSS towfish turned on for more than 5 minutes while out of the water. These are water-cooled systems and can be damaged by excessive heat buildup if left on when not deployed.

1.5.7.3 Documentation & Reporting Requirements

In addition to a SSS Calibration Table, a chartlet showing the test area, actual target position, test line plan, positions of successful detections, and approximate 95% Confidence Radius for the target location shall be created for each system tested. The exact format of these chartlets is left to the discretion of the hydrographer. This information shall be maintained by the field unit and available for review during Hydrographic Systems Reviews and at the request of OCS. Documentation for SSS Calibration Tests conducted shall be included with the DAPR for each associated project.

There is no requirement to individually document and report SSS confidence checks required in section 1.5.7.2 above. Hydrographers shall verify that these checks were conducted, describe the results, and discuss any problems encountered in the Quality Control section of each applicable Descriptive Report.

1.5.8 Tide Gauges

Tide gauges are used to measure water levels for calculating bathymetric data correctors. In any given tidal area, water level data account for the largest vertical correction to soundings. However, water levels vary due to both astronomical tides and effects from other forces such as wind, rain, barometric pressure, and freshwater runoff. Even in areas where tidal range is small, such as the Gulf of Mexico, the total water level variations can still be large enough to significantly affect sounding accuracy. If water level values are not properly measured and applied, then hydrographic error budget requirements may not be met.

1.5.8.1 Calibration Requirements & Methods

Tide gauges, batteries, GOES antennas, battery cables, regulators, and other tide gauge equipment are typically maintained and calibrated (if necessary) by CO-OPS staff on an annual basis. Field units should contact the local Operations Branch of the CO-OPS Field Operations Division immediately after the close of the field season to arrange for servicing of any gauges deployed with the unit. As the field unit prepares for the upcoming field season, the unit should discuss tide gauge requirements with FOD as soon as project assignments are known.

Field units should thoroughly test all tide gauge equipment, including that serviced by CO-OPS, as part of the Hydrographic Systems Readiness Review process.

1.5.8.2 Periodic Quality Assurance Checks

When a field unit installs a tide gauge for hydrographic surveys, it is responsible for operation and maintenance of that gauge for the duration of the survey. As such, it behooves the hydrographer to conduct a full functional check of all gauge equipment immediately prior to installation. Once the gauge is installed, the following checks should be conducted:

- The hydrographer should monitor the daily Hydro Hotlist email to ensure that gauge data are being received by CO-OPS and pass quality checks. (Note: the hydrographer must specifically request CO-OPS to add gauges to the Hydro Hotlist. See Section 3.4.2.3.1 for additional information.)
- If GOES transmissions are not possible from the tide station site, the hydrographer should visit the station every few days to ensure to ensure that data are being recorded. The hydrographer should download recorded data on these visits, check the water levels to ensure a smooth curve consistent with predictions (if available), and transmit the data to CO-OPS.
- Regardless of the status of the satellite uplink, the hydrographer should visit the station site approximately weekly to check the physical integrity of the installation. These checks should include the following:
    - Confirm that gas pressure is adequate to last until the next visit, and check for gas leaks at tubing connections (for bubbler gauges).
    - Check battery voltage to confirm that the solar cells are providing adequate charging current.
    - Check for physical stability of the gauge by performing a minimum of 1 hour of staff readings for comparison with recorded data.
- These station checks are particularly critical immediately before and after an extended absence from the survey area (such as a port call).

If problems are observed with water level data an on-site assessment should be conducted and field units should contact CO-OPS to determine the preferred course of action.

1.5.8.3 Documentation and Reporting Requirements

Since tide gauge equipment is maintained by CO-OPS, annual field unit calibrations are not required. Tide gauges do not need to be addressed during Hydrographic Systems Reviews aside from being listed in the Hardware Systems Inventory. Any tide gauge problems encountered during survey operations shall be described, including any subsequent effects to survey data, in applicable DAPRs or DRs.

1.5.9 Leveling Equipment

Geodetic leveling equipment is used to measure elevation differences between benchmark locations and to extend vertical control from established benchmarks to water level measuring equipment or a water level staff. For hydrographic survey operations, this equipment consists of a compensator leveling instrument and level rod. The quality of the vertical datum measured is partially dependent on the quality of the leveling performed between benchmarks and the water level staff or equipment. It is important to properly maintain leveling instruments and rods to ensure that they are within calibration tolerances.

It is OCS policy to follow the standards and procedures established by CO-OPS for calibrating and operating leveling equipment used to survey water level stations. These requirements are described in the NOS User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations (User's Guide), published by CO-OPS and included on the Hydrosoft DVD. These requirements are summarized here, but the hydrographer should refer to the User's Guide for specific information on leveling operations.

1.5.9.1 Calibration Requirements & Methods

For OCS hydrographic survey operations, level surveys shall be conducted to at least third order accuracy standards. The minimum scale calibration standard for level rods being used for third order surveys is the manufacturer's standard. Level rods do not have a recommended time period between scale calibrations. If an error is suspected in a rod scale, the rod may be calibrated and certified by an approved laboratory.

No leveling instrument is perfectly aligned. The angle from which the line of sight departs from the actual level surface when the instrument is leveled is referred to as collimation error. To minimize collimation error, the leveling instrument shall be serviced and adjusted during Annual Systems Preparation and whenever a collimation error cannot be reduced to acceptable tolerances in the field. This service shall be performed by a qualified, manufacturer-approved technician.

The hydrographer shall verify the collimation of leveling instruments after annual calibration. Collimation shall be checked according to either of the two approved methods described in section 3 of the User's Guide. The collimation error should be no greater than ± 0.05 mm/m. If it exceeds this tolerance, the level instrument must be adjusted and another check performed. Collimation Checks shall be processed and documented on NOAA Form 75-29 (or an equivalent) according to the procedure and example in section 3 of the User's Guide.

1.5.9.2 Periodic Quality Assurance Checks

Collimation and general performance of leveling equipment shall be verified prior to each leveling survey by repeating the collimation check. If collimation error exceeds ± 0.05 mm/m, the level instrument must be adjusted and another check made until the error can be successfully reduced below this threshold.

1.5.9.3 Documentation and Reporting Requirements

Collimation check and calibration records for leveling equipment used for OCS hydrographic surveys shall be maintained by the field unit and available for review during Hydrographic Systems Reviews and at the request of OCS. Leveling equipment and dates of calibration shall be reported in the Hydrographic Systems Inventory. Documentation for any subsequent collimation checks and/or calibrations conducted shall be included in the DAPR for each applicable project.

1.5.10 Horizontal & Vertical Control Equipment

No standard calibration requirements have been implemented at this time for horizontal and vertical control equipment. This equipment should be maintained per the manufacturer's recommendations until further guidance is provided.

1.5.10.1 Calibration Requirements & Methods

No standard calibration requirements have been implemented at this time for horizontal and vertical control equipment. This equipment should be maintained per the manufacturer's recommendations until further guidance is provided.

1.5.10.2 Periodic Quality Assurance Checks

No periodic quality assurance checks have been implemented at this time for horizontal and vertical control equipment. This equipment should be periodically checked per the manufacturer's recommendations until further guidance is provided.

1.5.10.3 Documentation & Reporting Requirements

Calibration and quality assurance documentation for horizontal and vertical control equipment used for hydrographic surveying shall be maintained by the field unit and available for review during Hydrographic Systems Reviews and at the request of OCS. Horizontal and vertical control equipment and dates of calibration (if applicable) shall be reported in the Hydrographic Systems Inventory. Documentation for any subsequent calibrations or quality assurance checks conducted shall be included in the DAPR for each applicable project.

1.6 Software Systems

Computer software plays an essential role in NOAA's hydrographic surveying operations and must be managed with care and attention to detail. Hasty dissemination of new programs and updates to field units may allow for rapid resolution of problems and implementation of new features, but can also lead to fragmented, nonstandard configurations across the fleet. For this reason, it is important that each field unit ensure, at least during Annual Systems Preparation, that their systems are up-to-date with the most current approved versions of survey related software.

Software packages will evolve, through various versions and updates, during the course of a field season. Field units will typically want to operate with the most up-to-date software available; however, it should be noted that application of newly released updates in a production environment can have unforeseen consequences that may adversely impact efficiency and data quality. Any mid-season software changes should be carefully documented so that the field unit can revert to a prior software version if problems arise. OCS has established the following basic guidelines for maintaining, updating and testing software.

All field units should incorporate adequate computer and software maintenance periods into their annual schedules. This should be planned to coincide with a period of relatively low operational activity, typically winter inport for ships. Field units should use this opportunity to install and configure software on new computer systems and conduct comprehensive rebuilds of systems to be retained. In general, “rebuilding” a system entails the following steps:

1. Back-up all storage devices attached to the system (local hard drives).
2. Reformat storage devices
3. Complete any scheduled hardware upgrades (new drives, memory, etc.)
4. Load the latest approved version of the operating system and mission software (standardized to the greatest extent possible across the platform).
5. Restore only essential data from the back-up.

This practice has been particularly useful on Microsoft Windows-based systems with multiple users, as it enforces software and configuration standardization and limits retention of unnecessary data or software that may adversely affect system performance.

NOAA personnel seeking information on hydrographic software updates should consult HSTP. HSTP is the first point of contact for most commercial hydrographic software packages in use by NOAA hydrographic field units and is directly responsible for writing and maintaining many of the in-house programs used for OCS surveys. Prior to installing software upgrades, it should be ascertained that the new version or update has been tested and approved for use. The field unit’s regional HSTP Field Support Liaison should be able to answer questions about software availability and testing.

Aboard NOAA hydrographic survey ships, EED shares responsibility for maintenance of hydrographic survey computer systems and software. Traditionally, EED has maintained computer hardware, operating systems, and data acquisition software, while OCS has been responsible for survey planning and data processing software, but these lines are often blurred. Shipboard hydrographers should, therefore, coordinate all software requests and changes with the embarked Electronics Technician, as well as with HSTP.

There will be cases where a critical software problem warrants installation of an upgrade before HSTP or EED has rigorously tested and/or verified its functionality. Hydrographers are encouraged and expected to exercise common sense in these cases. If external testing is not possible, field units should establish an internal software test program, document the procedures and results, and report their findings to HSTP and EED, so other units can benefit from their experience.

1.6.1 Types of Software Systems

1.6.1.1 Computer Operating Systems (OSs)

The operating system is a computer’s most fundamental software and it affects the performance of all other programs running on a machine. Typically, NOAA’s hydrographic survey computer systems use the Microsoft Windows environment. New versions or significant updates (such as Service Packs) for any OS should not be installed until the hydrographer has consulted both EED and HSTP. These groups must confirm that mission-critical software has been successfully tested under the proposed new OS version prior to installation on any system used for hydrographic survey operations. OCS discourages major mid-season OS upgrades (for example, switching from Windows 2000 to Windows XP) and suggests that field units attempt to maintain a standard OS on all data acquisition and processing systems.

OCS will not notify field units of available OS upgrades unless the update is critical to maintain functionality or compatibility with hydrographic systems. However, most OS vendors have an automatic notification system for critical updates. Field units with Internet access can also check the OS vendors' websites to determine if updates are available. Complete OS upgrades should be acquired through EED (if shipboard) or via the field unit's chain of command.

1.6.1.2 Data Acquisition Software

Data acquisition software is used to directly control hydrographic survey equipment and log digital data acquired by various survey instruments. These programs are considered the most critical software aboard a hydrographic survey platform, and extreme care must be exercised when installing or updating the systems. Installing software with new features, and possibly bugs, can produce data that appear normal at the time of acquisition, but are later found to contain errors. In such cases, the data may be uncorrectable and completely unusable, resulting in a significant loss of efficiency while the area is resurveyed. Common hydrographic data acquisition software packages used by NOAA field units are presented in Table 1.1.

Software Package	Manufacturer	Common NOAA Uses
HypackMAX	Hypack	VBES and MBES acquistion; survey line navigation
IsisSonar	Triton Imaging	SSS and MBES acquistion; survey line navigation
HydroStar	Elac	MBES acquisition
SonarPro	Klein	SSS acquistion
SIS	Kongsberg	MBES acquisition

Table 1.1: Common OCS Data Acquisition Software Packages.

OCS recommends that data acquisition software updates be performed during Annual Systems Preparation. Field units wishing to install updates during normal operational periods shall contact the regional HSTP Field Support Liaison to determine if the new version has been successfully tested in a controlled environment. Occasionally, it may be necessary to install a critical update without prior HSTP testing. In such cases, field units should first document the existing software version settings so that it can be reinstalled if the update causes more severe problems. The software upgrade should then be installed on a limited basis to minimize the effects of any bugs encountered. Proper testing of new software may require several days of standard field operations to fully assess its functionality. Field units should process and thoroughly examine resulting data for errors prior to making a unit-wide installation.

HSTP maintains support agreements with most manufacturers of data acquisition software packages used by OCS. Although some companies may contact individual licensees directly when updates are available, this communication is typically routed through HSTP or EED. When a period of relative inactivity suitable for computer system maintenance is approaching, field units should contact the regional HSTP Field Support Liaison and assigned EED Electronics Technician (if applicable) for any approved data acquisition software upgrades that are available.

1.6.1.3 Data Processing Software

Data processing software are those programs used to manipulate and analyze survey data. Typically, data processing mistakes or errors can be repaired by simply repeating a step or, at worst, by reconverting and reprocessing the raw data. Although reconverting and reprocessing can lead to time consuming rework, the results of data processing software problems are generally not catastrophic. Common hydrographic data processing software packages used by NOAA field units are presented in Table 1.6.1.3.

Software Package	Manufacturer	Common OCS Uses
HIPS / SIPS	CARIS	bathymetry and imagery data processing
Notebook	CARIS	survey planning and processing
MapInfo	MapInfo	survey planning; survey product creation
Fledermaus	IVS 3D	3D survey data visualization
Pydro	NOAA	survey data analysis; report creation; TCARI tide application
Velocwin	NOAA	sound velocity profile processing
Hydro MI	NOAA	survey line planning; tide file creation

Critical updates for data processing software may be issued frequently, often leaving HSTP with insufficient time to thoroughly test each update before implementation in the field. In such cases, field units should install updates on a limited basis and test basic functionality prior to making a unit-wide installation.

HSTP maintains software support agreements with most data processing software manufacturers, many of which notify users directly when new updates are available. The following update procedures for specific processing software packages have been established by OCS:

- CARIS products: All NOAA hydrographic field units should be receiving weekly email from CARIS describing any new releases. Any field units not subscribed to this service should contact the regional HSTP Field Support Liaison to register.
- HSTP products (Pydro, Hydro_MI, Velocwin): HSTP will notify field units directly when critical updates are available.
- IVS 3D: Units interested in receiving email notification of Fledermaus updates can subscribe to the IVS email list. See `http://www.ivs3d.com/support/mailing_list.html` for more information.
- MapInfo: All MapInfo licenses are covered under a global maintenance plan managed by HSTP. HSTP will notify field units directly when critical MapInfo updates or patches are available.

1.6.1.4 Support Software

Support software includes any packages that are used as part of the hydrographic survey process, but do not directly interact with data. However, they may be used to create digital products that accompany survey data and, as such, must be compatible with systems throughout OCS. Examples of support software that may be in use by a field unit include NOAA Chart Reprojector, Paint Shop Pro or AutoCad.

Although OCS does not notify field units of upgrades to these packages unless there is a pressing operational need, most vendors provide email update notification to registered users. Field units should coordinate with OCS to ensure that support software is in compliance with NOAA standards and compatible with survey systems.

1.6.2 Software Repositories

Once a field unit has determined that a software upgrade is approved, available, and desirable, the digital files must be acquired. While some vendors will provide these upgrades on physical media, users are often expected to download updates via File Transfer Protocol (FTP) or from Internet websites. HSTP posts both commercial and in-house software upgrades to OCS's anonymous FTP server (IP address 205.156.4.84). Note: NOAA field units can not upload data to the FTP server.

If field units are outfitted with reliable high speed Internet access, software can be easily downloaded from vendor sites or the FTP server. However, some of NOAA's hydrographic field units have limited bandwidth for accessing the Internet or for receiving email attachments; thus, an alternate means of obtaining software upgrades may be necessary. Field units should consider other connection sites, such as public libraries or Internet cafés, or contact the regional HSTP Field Support Liaison to have updates mailed on CD or other media.

1.6.3 Documentation & Reporting Requirements

Each computer used to acquire or manipulate hydrographic survey data shall be included on the Software Inventory portion of the Hydrographic Systems Inventory. Installations and updates for primary software packages shall be recorded for each computer, as shown by the sample data (red font) included on the Software Inventory spreadsheet. Additionally, a record of system settings for hydrographic data acquisition software shall be created and updated throughout the field season. If a software system has the capability to output a file identifying all configuration settings (e.g., ISIS survey.log file), a copy of this file will meet system settings reporting requirements. Otherwise, the field unit will need to manually generate a digital record (e.g., a spreadsheet).

Software documentation shall be maintained by the field unit and available for review during Hydrographic Systems Reviews and at the request of OCS. A copy of the Software Inventory and system settings records in effect during operations shall be included in the DAPR for each respective project.

1.7 Personnel Rosters

People are the most essential component of any hydrographic survey system, and training hydrographic personnel is a critical element of survey preparation for any field unit. Even if all hardware and software systems are functioning correctly, data quality and operational efficiency will suffer without properly qualified hydrographers. Guidelines for training and qualification of hydrographic personnel are described below.

For the purposes of this manual, "hydrographic personnel" are defined as those members of a field unit's complement (permanent or temporary duty) whose normal duties include responsibility for any activities that directly affect survey planning, data acquisition, or data processing. In addition to Physical Scientists, Survey Technicians, Commissioned Officers, and others in immediate control of survey operations, this includes launch coxswains and Officers of the Deck (OODs) responsible for operating vessels during surveying; visitors who participate in data acquisition and processing without direct supervision; and the unit's command. Support personnel, such as marine engineers, stewards, and members of the deck department not acting as launch coxswains, are not typically considered "hydrographic personnel". However, if survey operations will be significantly impacted by any of the aforementioned groups, e.g. an insufficient number of engineers to perform planned 24-hour operations, these situations should be mentioned in the Hydrographic Systems Readiness Memo described in 1.1.1.

1.7.1 Personnel Qualifications & Training

Standard hydrographic training and qualification requirements are not currently established for NOAA's hydrographic personnel. Therefore, it is incumbent on each field unit to establish internal standards to ensure that hydrographic personnel are adequately qualified to safely and efficiently accomplish the unit's mission. Such a program of training and qualification can be crafted from any of several available components including, but not limited to, the following:

1.7.1.1 Internal Training and Qualification Standards

These are standards of training and qualification developed by the field unit to meet the particular needs of its configuration and mission. Examples include:

- Launch Hydrographer-in-Charge (HIC) workbook and qualification
- Launch Person-in-Charge (PIC) workbook and qualification
- Launch Coxswain workbook and qualification
- Officer Of the Deck (OOD) workbook and qualification

1.7.1.2 NOAA Hydrographic Training

The Office of Coast Survey organizes an annual basic hydrographic training program ("Hydrotraining"). One session per year is offered at a location on each coast, typically Norfolk, VA and Seattle, WA, and all new survey personnel are encouraged to attend. Subject to demand and available funding, sessions on advanced topics suitable for hydrographers with more than one year of experience may also be offered in conjunction with the basic course.

CO-OPS is available to provide training on basic tidal theory, tide gauge installation, discrete tide zoning and TCARI methodology. Elements of these topics are covered in basic hydrotraining, but field units may choose to schedule additional training with CO-OPS to meet their specific needs.

1.7.1.3 External Training

Hydrographers may be eligible to pursue hydrographic qualifications from an outside agency or organization such as the American Conference on Surveying and Mapping (ACSM).

1.7.2 Reporting Requirements

Although the Hydrographic Systems Inventory includes only a basic roster of hydrographic personnel, deficiencies in either numbers or qualification of personnel should be noted in the Hydrographic Systems Readiness Memo described in 1.1.1.

Additionally, OCS recommends that each field unit maintain a record of personnel training and qualifications. Formally documenting personnel training and qualifications will assist Chiefs-of-Party in assessing the readiness of their personnel. This record can also help identify hydrographic training needs, enabling units to request and allocate resources accordingly. Copies of curriculum and/or requirements for any internally crafted qualification or training should be maintained by the field unit for reference purposes.

Chapter 2

Pre-Survey Planning

> In preparing for battle I have always found that plans are useless, but planning is indispensable. – Dwight D. Eisenhower

Pre-survey planning is essential for any field unit to effectively and efficiently conduct hydrographic survey operations. When planning operations, the hydrographer must keep in mind the assigned survey specifications and approved methods for meeting those criteria. This Chapter describes information that will be provided to a field unit when a hydrographic survey is assigned and provides project preparation and survey planning guidance.

2.1 Crew & Vessel Safety

Above all, every member of the field party should understand that safety of the crew and vessel is the number one priority. Safety shall be the foremost consideration in all aspects of Office of Coast Survey (OCS) hydrographic surveys, from the planning stages through data submission. It is the responsibility of the Chief-of-Party, as well as vessel crew, to be aware of safety hazards and take steps necessary to ensure undue risks are avoided, even if it means ceasing operations.

Good planning and information can minimize risks associated with hydrographic surveying.

Recommended practices to increase safety include, but are not limited to the following:

- Use historical weather information to prepare for seasonal patterns.
- Review the survey region for exposed areas, constricted areas, shallow areas, surf, etc. Plan on surveying challenging areas when weather, tides, and currents are optimal.
- Review prior survey Descriptive Reports (DR) and smooth sheets for uncharted hazards. Often, the DR will describe deficiencies, hazards, and challenges from prior surveys and field experience.
- Work progressively from safe water towards unknown, shallow, or potentially hazardous areas.
- Use daily survey information progressively in the field to minimize hazards. Communicate survey and safety information to all personnel involved in operations.
- Read AWOIS descriptions to understand hazards and survey the feature safely.

- Understand the limitations of charted and source information and approach features conservatively during initial operations.

2.2 The Project CD/DVD

When a hydrographic survey is assigned, the HSD Operations Branch (OPS), or the NSD Navigation Response Branch (NRB) if the unit is an NRT, will generate and compile relevant project information onto a Project CD/DVD. This information will include project instructions, as well as supporting information and data files to be used during field operations and subsequent survey processing. Copies of the Project CD/DVD will be disseminated to the field unit and appropriate hydrographic branch (AHB or PHB). The file structure illustrated in Figure 2.1 represents that of a typical Project CD/DVD.

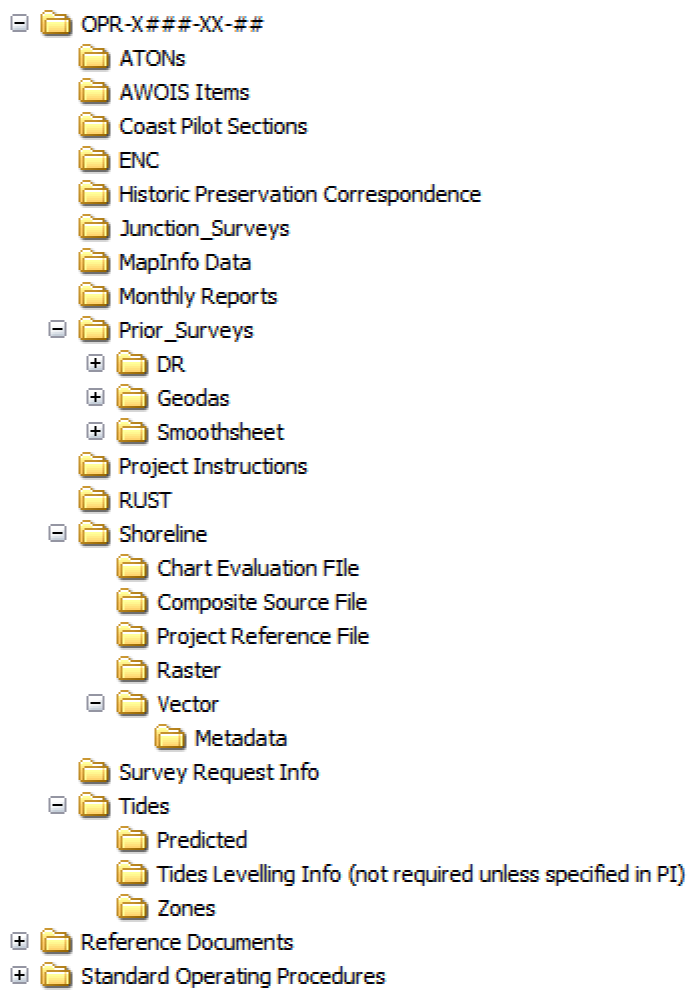

Figure 2.1: Project CD Directory Structure.

2.2.1 Hydrographic Survey Project Instructions

The Hydrographic Survey Project Instructions (formerly called Letter Instructions) will identify specific requirements for a survey project. Project Instructions will be included on the Project

CD/DVD and can be equated to a Requirements Document or Statement of Work. Field units shall acknowledge receipt of Project Instructions via email to the assigned OPS Project Manager or the NRB Technical Assistant.

2.2.2 Supporting Project Information

Extensive supporting project information will be provided on the Project CD/DVD. The following items are typically included: AWOIS database records, MapInfo tables and workspaces, shoreline files, preliminary tidal zoning, a monthly reporting template, data, imagery and metadata for prior and junction survey coverage, various reference guides, copies of the latest NOAA ENCs and raster charts, relevant Coast Pilot sections, historic preservation correspondence, and records for ATONs to be positioned. The naming conventions for project information files generated at OPS or NRB may vary slightly, but will typically reference the applicable project number or survey sheet number.

2.2.2.1 Aids to Navigation (AToN) Records

NOAA's Update Service Branch (USB) will review NOAA's Critical Corrections Database (CRIT) and/or USCG Integrated Aids to Navigation Information System (IATONIS) database to identify ATONs within the survey area that require positioning. Records for each assigned ATON will be provided by USB for inclusion on the Project CD/DVD. ATON records will include the current database position for each assigned ATON, position accuracies or positioning methods that were used (if available), and any special positioning requirements.

2.2.2.2 Automated Wreck and Obstruction Information System (AWOIS)

AWOIS is a database of wrecks and obstructions in the coastal waters of the United States that includes each item's position, a brief history, and other descriptive details. Items in the database may have been found during hydrographic surveys or reported by miscellaneous sources. If an AWOIS record has been disproved, the item will typically remain in the database with a disproval noted. It is rare for a record to be deleted from the AWOIS database; thus, not all AWOIS items will appear as features on the current nautical chart. The OPS Project Manager or the NRB Technical Assistant will assign AWOIS items to the field unit for investigation. AWOIS search radii are assigned based upon extensive research of historical documents and factors such as the original source of the feature and the quality of that feature's positioning. Records for assigned AWOIS items will be provided on the Project CD/DVD in MS Access format, with corresponding MapInfo tables. This subset of the master AWOIS database will contain all items falling within the limits of the particular project, as well as any critical items in close proximity to the survey area.

Prescribed investigation requirements for each AWOIS item will be specified in its database record. The AWOIS Database User's Guide, included in Appendix 2 (AWOIS_Database_User's_Guide.pdf), contains an explanation of each field within an AWOIS record. The database record number, assignment status, type of investigation required, minimum search radius (in meters) for disproval, acceptable methods for disproval, and any special investigation requirements will all be included in the AWOIS record. If an item has been "Assigned" with a "Full" search, an investigation of the entire assigned search radius, using a prescribed method, shall be conducted by the field unit, provided the investigation can be completed safely. Some AWOIS items may be "Assigned" for "Information" purposes only. These items may have been previously disproved or recently verified and would not warrant a specific investigation unless the record is found to be in error by the current survey. In such cases, a "Full" investigation shall be conducted for the item. “Unassigned” items are provided as a reference for possible feature correlation. These items do not require an investigation, nor should they be addressed in the Descriptive Report unless detected during survey operations. Questions regarding AWOIS items or the AWOIS database should be directed to the OPS Project Manager.

2.2.2.3 Coast Pilot Sections

Sections of the Coast Pilot pertaining to the largest scale chart that encompasses the project area shall be reviewed for additions and discrepancies in accordance with section 3.5.6 of this manual. The NSD Coast Pilot Branch will provide digital copies of relevant Coast Pilot sections for inclusion on the Project CD/DVD. The date of last revision for the Coast Pilot data provided will be clearly identified in the digital file.

2.2.2.4 Electronic Navigational Charts (ENCs)

This directory will include all ENCs affected by the project area. The supplied ENCs will be the latest editions available to OPS or NRB at the time the Project CD/DVD is created. The most current official ENC available to the field unit, which may not always be the edition originally provided on the Project CD/DVD, shall be used for comparison to survey data. Both Local Notice to Mariners (LNM) and Notice to Mariners (NTM) publications should also be consulted periodically to identify new chart corrections.

Guidance documents for encoding S-57 objects will also be included in the “Reference Documents” directory. If an ENC needs to be viewed in a GIS environment, a converter may be downloaded from the NOAA Coastal Services Center website `http://www.csc.noaa.gov/bins/tools.html`.

2.2.2.5 Historic Preservation Correspondence

OCS, as a unit of a federal agency, has responsibilities under Section 106 of the National Historic Preservation Act (NHPA, 16 U.S.C. 470 et seq.) to take into account the effects of its undertakings on historic properties. The process for federal agencies in complying with the NHPA is laid out in 36 C.F.R. Part 800, which prescribes consultation with the State Historic Preservation Officer (SHPO).The files related to that consultation will be saved in this folder. The Hydrographic Surveys Division is responsible for taking care of the consultation process. HSD will simply but the correspondence in this folder as background information for the field units.

2.2.2.6 Junction Surveys

All field units are required to ensure continuity in survey coverage and depth by evaluating junctioning or overlapping surveys. Assigned surveys may include a junction with contemporary data from a recent field season. If these junction survey data are not provided on the Project CD/DVD, they should be available either on the field unit’s data storage devices or from the appropriate hydrographic branch. If historical junction survey data are available, the Project CD/DVD will include both the Descriptive Report and a raster image of the smooth sheet for each survey, if available. Raster image files will require manual geographic registration in MapInfo. The OPS Project Manager or NRB Technical Assistant may register one or more of these raster files while performing historical research. In such cases, the corresponding Map-

Info file will also be provided. The Project Instructions will indicate if a junctional survey is in a projection and datum other than UTM NAD83 and requires a datum conversion or reprojection.

2.2.2.6.1 Junctioning with Light Detection and Ranging (LIDAR) Surveys LIDAR junction data will be provided in S-57 (.000 or .HOB) format on the Project CD/DVD. In most cases, features found by the LIDAR survey will be added to the Composite Source File (CSF) as an existing feature. However, in some cases due to complexity these features may remain as standalone S-57 files. LIDAR investigations will be added to the Project Reference File (PRF). Field units should obtain the required coverage type to the LIDAR extent line or the Navigation Area Limit Line (NALL), whichever is further offshore. Verify or disprove all LIDAR investigation items seaward of the NALL. The following list of table indicate typical LIDAR deliverables.

TECSOU ‘found by laser’ should be used for all LIDAR items. Maintaining the ‘found by laser’ TECSOU is the best way to sort out LIDAR features from others on the Field_Verified and Disprovals hob layers. For instance, a LIDAR item is edited for height, so it adopts the new survey’s SORDAT and SORIND, but the TECSOU remains “found by laser”. This will alert PHB that the feature originated from LIDAR.

For LIDAR features that are non-investigation items that lie outside of the LIDAR Good Line (LGL), because they lie outside the LGL there will be presumably full coverage over the feature using techniques that supersede LIDAR (MBES, SSS, DLDG and VBES). These LIDAR features can be ignored as far as deliverables are concerned and used as For Your Information Purposes Only to aid in planning and safe boat operations.

The standard practice for coverage overlap between LIDAR and MB surveys is to overlap one swath width inshore of the LGL.

The following files will be included on the Project CD/DVD for juctioning with LIDAR data.

File Name	S-57 Object	Description
Hxxxxx_LI_Feat.000 Hxxxxx_LI_Feat.hob	[various]	All features detected by LIDAR.
Hxxxxx_LI_Inv.000	BUAARE	Placeholder indicating features recommended for field verification.
Hxxxxx_LI_Inv.hob	$LINES	LIDAR junction line.

Table 2.1: S-57 and CARIS HOB files included on the Project CD/DVD for junctioning with LIDAR data.

File Name	Description
Hxxxxx_LI_BASE_3m	3 meter resolution surface.

Table 2.2: CARIS file included on the Project CD/DVD for juctioning with LIDAR data.

File Name	Description
Hxxxxx_DR.pdf	Descriptive report and appendices.
Hxxxxx_LI_ChartComp.xls	LADS chart comparison results.

Table 2.3: Other files included on Project CD/DVD for junctioning with LIDAR data.

The following Objects were used as placeholders in the LI_Investigation and LI_Undected HOB files.

Object Class	Description
$CSYMB	An area where least depth was not determined due to poor water condition (Kelp, turbidity, etc. . .). A feature may exist within the vicinity.
M_NPUB	A charted feature that was not detected by LIDAR or not found in orthophoto.
UWTROC	A submerged rock with doubtful least depth value.

Table 2.4: Object classes used in HOB files for junctioning with LIDAR data.

The following common attributes are used to define feature objects in the deliverables.

Attribute	Description
INFORM	Unique ID number assigned to LIDAR features.
NINFOM	Remarks and description of the feature.
NOBJNM	Contains corresponding chart comparison ID
PICREP	Contains link to orthophoto
QUASOU	Features with uncertain least depth values are coded ’3’ for doubtful sounding.
SORDAT	Last date of survey
SORIND	Information about the source of the object. (US, US, nsurf, Hxxxxx)

Table 2.5: Object attributes used in HOB files for junctioning with LIDAR data.

For more information about the inclusion and treatment of LIDAR items in the Composite Source, refer to 2.2.2.11 and3.5.5.1.

2.2.2.7 MapInfo Data

The following MapInfo tables and workspaces will be included on the Project CD/DVD. Any MapInfo tables created by the OPS Project Manager or NRB Technical Assistant will be projected in Universal Transverse Mercator (UTM) using the North American Datum of 1983 (NAD83). Note: UTM NAD83 is not equivalent to Latitude/Longitude NAD83. For workspaces to open reliably, the entire “MapInfo Data” directory should be copied from the Project CD/DVD and “read only” flags removed from all files using Windows Explorer.

- Sheet Layout - The sheet layout provided will identify both the project and individual survey sheet limits, as well as the planned area of hydrography for each sheet. Sheet limits are typically rectangular by design and are used to divide large survey projects into smaller regions that can be easily managed. Specific planned areas of hydrography are designated by survey limits. Survey limits generally follow a certain depth contour interval. Layouts for Field Examinations (FEs) will vary according to the item, feature, or area to be surveyed.

- AWOIS Items - In addition to an MS Access file, AWOIS information will be provided using MapInfo tables and a corresponding workspace. Two separate MapInfo tables are typically provided. One file graphically displays item positions, with additional information in text format. The second file simply displays the assigned investigation limits for each item. Caution: When converting the MS Access file to a MapInfo table, some text fields may be truncated or even eliminated. Do not rely solely on the attribute and memo fields within the MapInfo table when planning an AWOIS item investigation in the field. The MS Access file should also be reviewed.

- Raster nautical charts - The Project CD/DVD will include all raster charts, in .bsb, .kap and .TAB format, that are affected by the project area. The supplied raster charts will be the latest editions available to OPS or NRB at the time the Project CD/DVD is created. The most current official raster chart available to the field unit, which may not always be the edition originally provided on the Project CD/DVD, shall be used for comparison to survey data. Both Local Notice to Mariners (LNM) and Notice to Mariners (NTM) publications should also be consulted periodically to identify new chart corrections.
- Tide zoning and tide stations - MapInfo tables and a workspace showing preliminary tide zones, water level reference stations, and tide zoning corrector values based on these reference stations will be included on the Project CD/DVD when discrete zoning is used. When TCARI is used for tidal correctors, MapInfo files are not generated. Duplicates of these files will be located in the Tides directory.
- Miscellaneous Information - Additional information such as limits of prior surveys, topographic maps, shoreline files, and DGPS coverage tables may also be provided on the Project CD/DVD.

2.2.2.8 Monthly Reports

For the purpose of submitting the required Monthly Survey Progress Estimates, Project Statistics, and Vessel Utilization Reports, HSD Operations Branch will provide each ship with an Excel workbook containing one worksheet for each of the three required components. The workbook will be sent to the ships at the beginning of the field season and will contain documentation for all planned hydrographic projects for the field season. As the field season progresses, any updates to the workbook such as newly planned projects will be saved in the Monthly Reports directory of the Project CD.

The information in these reports is vitally important for the management of the hydrographic survey program and is expected to be useful in the justification of additional resources in an increasingly competitive budget environment. Interest in improved metrics has been expressed by offices outside of OCS including the Office of Management and Budget (OMB), the Hydrographic Services Review Panel (HSRP) and NOAA's Office of Marine and Aviation Operations (OMAO).

See 5.2.3.2.1 for details on reporting requirements.

2.2.2.9 Prior Surveys

The Project CD/DVD will include the Descriptive Report and a raster image of the smooth sheet for all available prior surveys in the assigned area. OPS or NRB will reduce the size of these files as much as possible without loss of resolution. The raster image files will require manual geographic registration in MapInfo. One or more of these raster files may have been registered during historical research. In such cases, the corresponding MapInfo file will also be provided. The Project Instructions will indicate when a prior survey is in a projection and datum other than UTM NAD83 and requires a datum conversion or reprojection.

2.2.2.10 Resources and Undersea Threats (RUST)

RUST is a database maintained by NOAA's National Marine Sanctuaries Program (NMSP) that contains information on sensitive undersea resources and threats. This database may include items such as coral reefs, unexploded ordinance, and potentially hazardous or historical wrecks both in and outside the coastal waters of the United States. RUST information is compiled from multiple data sources, and will include each item's position (or approximate position), the type of feature, and other descriptive details if available. The OPS Project Manager or the NRB Technical Assistant will include RUST database information on the Project CD/DVD in both MS Excel spreadsheet and MapInfo table formats. A list of attribute definitions for the RUST spreadsheet is included in Appendix 2 (GlobalWrecks Attribute Table.pdf). This document provides a description of RUST database fields and definitions of codes used to populate the fields. RUST items are provided for background information only. A full investigation is required only if a RUST item is detected during main scheme hydrography. Questions regarding RUST items or the RUST database should be directed through the OPS Project Manager.

Note: RUST database information is considered sensitive and is often protected from release to the public. RUST information should be made available to personnel only as needed to complete survey operations, and should not be disseminated to persons or organizations outside the field unit without prior approval from the HSD Chief of Operations.

2.2.2.11 Shoreline Files

The Physical Scientists from Operations Branch will compile all available shoreline source files into one "composite source" file in S-57 .000 format. Shoreline source files include: ENC, RNC, Geographic Cells (GCs – also labeled as DCFF), prior surveys, and LIDAR files. Compilation will include using cartographic judgment to modify the feature layer to best represent the shoreline. Any features which cannot be deconflicted by Operations Branch will be attributed as such and placed on to a separate layer called the Discrepancy layer. This Discrepancy layer will also include AWOIS items and LIDAR investigation items.

If shoreline verification is not required, the project information directory will be empty on the Project CD/DVD.

2.2.2.12 Tides

The NOAA Center for Operational Oceanographic Products and Services (CO-OPS) provides three basic types of water level data, "predicted tides," "preliminary water levels" and "verified water levels" referenced to MLLW or other appropriate chart datum. All of this data can be downloaded from the CO-OPS website. Typically, CO-OPS posts preliminary water level data within a few hours of data acquisition. Stations included on the Hydro Hotlist (see 3.5.2.3.1) are processed weekly and verified water level data is typically available at the start of the following work week.

The CO-OPS Hydro Planning Team (HPT) also supplies discrete zoning or TCARI to estimate water levels across the entire survey area where the water level characteristics may vary from those where tide gauges are located. Historical water level station information, including the location of each station site, benchmark description and elevations, and historical datum references will also be provided if historical tide stations need to be reoccupied.

Predicted tides using 6-min format will be supplied on the Project CD/DVD.

2.2.2.13 Survey Outline Template

Survey Outlines are used to provide final values for square nautical miles surveyed, which are then deducted from the NOAA Hydrographic Survey Priorities total area. Field units shall submit a survey outline to OPS as soon as practicable upon completion of all data acquisition and an initial data quality review for a survey sheet.

The OPS Project Manager or NRB Technical Assistant will include on the Project CD/DVD a MapInfo table template (SurveyOutline.TAB) and a PowerPoint demonstration for generating a survey outline region. All survey outlines shall be created in NAD83 and portray the area of actual hydrography completed. Actual hydrography completed is defined as the bounding polygon encompassing the gridded BASE surface and/or side scan mosaic in areas of complete or object detection coverage. In areas of partial bottom coverage, actual hydrography completed is defined as the bounding polygon encapsulating the area where survey data has been acquired at the line spacing specified in the Project Instructions. Survey outlines shall be submitted, via email, to survey.outlines@noaa.gov.

2.2.2.14 Survey Request Information

The OPS Project Manager or the NRB Technical Assistant will include, if available, copies of documents from the maritime community, research groups, or other entity requesting the survey on the Project CD/DVD.

2.2.2.15 Reference Documents and Standard Operating Procedures

Reference documents provided on the Project CD/DVD will include the most recent versions (at the time of CD/DVD creation) of the FPM and HSSD, as well as any current Hydrographic Survey Technical Directives. Relevant SOPs such as the Field Encoding Guide, and Survey Outline Instructions will also be provided.

2.3 Additional Resources

Although the majority of information required to conduct an OCS hydrographic survey will be provided on the Project CD/DVD, additional resources such as training or reference materials may be necessary throughout a field unit's operating season.

2.3.1 Annual Hydrosoft DVD

The Hydrosoft DVD is produced and distributed annually by OCS's Hydrographic Systems and Technology Program (HSTP). This DVD provides an extensive amount of reference materials to the field units in a readily available and compact form, eliminating the need for carrying numerous reference books or using slow or unreliable internet connections. The following types of materials are included on the Hydrosoft DVD:

- Common survey software packages, both commercial and in-house.
- Software and hardware manuals and guides.
- NOAA hydrographic training presentations and resources.
- Nautical and navigation reference materials (e.g., Bowditch, Coast Pilot, Chart 1).
- NOAA Hydrographic survey references (e.g., HSSD, FPM, IHO documents).

2.4 Project Preparation

Once a field unit has received the Project CD/DVD, survey personnel should begin preparatory tasks such as reviewing project information, establishing a data management plan, contacting constituents, and planning horizontal and vertical control if necessary. These tasks are typically performed on a project-wide basis, prior to individual survey planning.

2.4.1 Project Information and Instructions

As soon as practicable, the field unit should inventory files provided on the Project CD/DVD to verify that all necessary information has been included. Once it has been confirmed that all files are present, project information should be copied to the field unit's computer systems in accordance with the unit's standard data management practices. Prior to any actual survey planning, it is recommended that the hydrographer review the Project Instructions and become familiar with the supporting files.

2.4.2 Data Management

Not only are a tremendous amount of data generated during a hydrographic survey, but field units are typically working on multiple surveys at any given time. Data management standards are critical for efficient surveying and can be easily established prior to survey planning and data acquisition. Guidelines for effective field unit data management are described in the following sections.

2.4.2.1 Digital Data Directory Structure

Data directory structures used during acquisition and processing may vary among field units. However, a standard should be in place within each field unit. It is important to adhere to any field unit directory standards, as some software configurations must reference specific directories. An example of a field unit directory structure is shown in Figure 2.2.

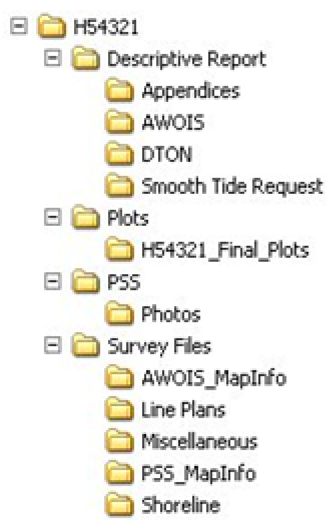

Figure 2.2: Survey data directory structure.

2.4.2.2 Digital File Naming Conventions

It is important to follow file naming standards within the field unit. Maintaining these conventions greatly assists AHB and PHB in identifying data records. Do not create data files with non-standard names that are unrelated to the file content and will confuse others who must access that data. Additionally, any preliminary, temporary, or extraneous files created by the field unit should not be included with data submitted to AHB or PHB.

2.4.2.3 Analog Records

If possible, all data should be submitted to AHB or PHB in digital format. In some cases, it may be necessary to acquire analog data (i.e., paper records) that can not be scanned into a digital record, such as a VBES fathogram. A folder and/or binder should be prepared for each survey sheet to file any such analog records. Each record should be labeled with at least the following information:

- Project number
- Survey registry number
- Vessel used to acquire the data
- Data type
- Date of acquisition Horizontal Control

Horizontal Control (HorCon) refers to the terrestrial network of geodetic marks that support two-dimensional hydrographic positioning. Typically, NOAA field parties use USCG differential beacons to correct GPS for hydrographic positioning. USCG differential correctors are subjected to an internal quality control process, ensuring a high level of accuracy. Additionally, USCG differential beacons have already been precisely positioned; thus, it is generally unnecessary for NOAA field units to establish horizontal control points when using this positioning method.

In remote survey locations or confined areas such as a fjord, USCG differential correctors may be unavailable or severely limited. For these areas, the field unit shall establish at least one horizontal control point where a portable DGPS control (“fly-away”) station can be installed. A review of the survey area should be combined with local knowledge to determine a feasible location. Keep in mind that public properties are usually preferred over private properties because special permissions will typically not be necessary for future access. However, equipment security must also be considered in populated areas which are easily accessible. Security measures may include locking instruments, affixing owner identification to equipment, and choosing a discrete station location. After a suitable location has been chosen, the field unit should obtain permission to access the property and install HorCon equipment. If it is necessary to drill into rock during the installation, permits should be obtained for this purpose.

Note: The Federal Aviation Administration’s Wide Area Augmentation System (WAAS) shall not be used as a positioning method for OCS hydrographic surveys. Although WAAS is sufficiently accurate for terrestrial navigation, it is a land-based system, and positional accuracy may not be consistent in the marine environment.

HorCon techniques may also be used to determine high accuracy DGPS positions for ATONs. If OCS’s Update Service Branch requires that an ATON be positioned using high accuracy HorCon methods, specifications will be noted in the ATON information provided on the Project CD/DVD. Typically, higher order ATON positions will be required for range lights.

2.4.3 Vertical Control

Vertical control refers to a network of geodetic marks that supports three-dimensional hydrographic positioning. Vertical control activities are typically conducted to support water level gauge installations and water level measurements. Personnel from CO-OPS are responsible for all planning of tide and water level requirements for OCS hydrographic surveys. CO-OPS will analyze historical data and tidal characteristics for each project area, specify operational NOS control stations, specify general locations for subordinate water level stations to be installed, and provide the tidal zoning (both preliminary and final) to be used during survey operations.

Installation, operation, and maintenance of controlling water level stations is typically the responsibility of the CO-OPS Field Operations Division (FOD). However, the hydrographic field unit may be required to install, monitor, repair, and/or uninstall a control water level station under the instructions of the CO-OPS FOD. The Project Instructions will state if installation, operation, and/or removal of subordinate water level stations is required for a project. In such cases, FOD will work in collaboration with the field unit to complete these tasks. The field unit will be responsible for ellipsoidal positioning of benchmarks near subordinate water level stations, in accordance with Section 4.2.5 of the HSSD.

To prepare for vertical control operations, the field unit should verify that all necessary equipment and tools have been obtained from CO-OPS. A sample equipment checklist for water level station installations is included in Appendix 2 (Wtr_Lvl_Statn_Equip_Checklist.xls). Several reference guides are available to assist the field unit with water level station procedures. The following manuals have been included on the Hydrosoft DVD for reference and can also be downloaded from the CO-OPS website `http://tidesandcurrents.noaa.gov/pub.html`:

- NOS User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations
- Specifications and Deliverables for Installation, Operation, and Removal of Water Level Stations
- CO-OPS User's Guide for Electronic Levels • CO-OPS User's Guide for Writing Bench Mark Descriptions
- CO-OPS User's Guide for GPS Observations
- CO-OPS User's Guide for 8210 Bubbler Water Level Gauge for Hydrographic Surveying Applications
- CO-OPS User's Guide for 8200 Acoustic Gauge

Additionally, the field unit should review any subordinate water level station locations specified in the Project Instructions and, if necessary based on local knowledge, recommend alternate sites to CO-OPS. Keep in mind that public properties are usually preferred over private properties because special permissions will typically not be necessary for future access. However, equipment security must also be considered in populated areas which are easily accessible. Security measures may include locking instruments, affixing owner identification to equipment, and choosing a discrete station location. Once locations have been agreed upon, survey personnel should obtain permission to access the property and install the staff, benchmarks, and gauge at the selected site.

2.4.4 Constituent Contact

The Project Instructions will list constituents who must be contacted at or near the beginning and end of field operations to discuss survey objectives and accomplishments. It is mandatory that the field unit contact the appropriate regional NOAA Navigation Manager as identified in the Project Instructions.

The Project Instructions will also list various local contacts for reference. These resources should not be overlooked and can often provide local knowledge regarding AWOIS items, shoaling, marine activities, traffic patterns, and other areas of concern. Local information sources include Port Authorities, Pilot Associations, local ferry companies, fishermen, towing companies, U.S. Coast Guard, U.S. Army Corps of Engineers, and local and state government agencies. Information regarding local survey requests or charting concerns that will not be addressed during the current project should be conveyed to either the Chief of Operations or the Chief of NRB.

2.4.4.1 Cultural or Historic Submerged Features

HSD Operations Branch will contact the State Historic Preservation Officer (SHPO) and Historical/Archaeological contact at the NOAA National Marine Sanctuaries Program (NMSP) office during preparation of Project Instructions to request information on any historically significant man-made features on the seabed within the survey area. Any information provided by these groups will be included in the Project Instructions. The Project Instructions will also include the contact information of the SHPO and NMSP for use in the event of discovery of a potentially historically significant man-made feature, in accordance with 4.4.5.

2.4.4.2 Potential for Lost or Damaged Fishing Gear

Occasionally, local fisherman or lobstermen will make a claim regarding lost or damaged fishing gear. Typically, when these claims are made NOAA may give compensation for the gear. In an effort to be pro-active and incorporate better coordination, the Operations Division will now contact fish/lobster organizations to inform them, prior to the field season, where a NOAA vessel will be working and the approximate time frame.

An additional mandatory point of contact will be listed in the Project Instructions for projects which have this potential to significantly interfere with the work of local fishermen/lobstermen. In those cases, the field unit vessel must use that point of contact to coordinate with the local fishermen/lobstermen in an effort to reduce the impact of hydrographic survey operations on their livelihoods.

If the situation arises where a state claims that NOAA has violated a State law where the vessel and its crew are engaged in operations authorized by Federal law (i.e. performing a survey mission), then a State may not detain or prosecute a Federal vessel's captain and crew for alleged violations of State law (e.g. it is a violation of Massachusetts law if someone destroys any lobster or other fishing gear and can be punished through a fine or imprisonment). For more information see the Memo from the General Counsel Office for Ocean Service in Appendix 2.

NOAA's policy and the process of addressing claims for loss or damaged gear is currently being reviewed and will be incorporated in the next version of the FPM.

2.5 Survey Planning

All surveys begun during a field season must be completed in that same field season. OCS recommends that systematic data acquisition plans be prepared prior to vessel operations. These plans may consist of lines used directly for vessel navigation, polygons used to designate survey areas if the acquisition software provides a real time coverage map, or target files used to mark pre-determined data acquisition points. Using a line plan for navigation assists the vessel operator in maintaining a straight trackline, potentially minimizing gaps, or “holidays,” in the data coverage. Target files can be used to navigate efficiently between data acquisition points, as well as to ensure a point feature is not missed during vessel operations.

When creating data acquisition plans, many factors must be considered, including the scope of the survey, object detection criteria, sheet layout with respect to surrounding features, available data acquisition systems, number of features to be addressed, traffic patterns, local currents, tide stages, and prevailing weather and sea conditions. Input from other survey personnel, particularly those who have previously operated in the area, can be invaluable when creating data acquisition plans. Proposed plans should be reviewed by the FOO and/or Chief-of-Party prior to vessel operations.

Depending upon the survey area, it may be prudent to create alternate data acquisition plans for daily operations. For example, if weather conditions preclude safe vessel operations in the planned survey area, an alternate acquisition plan in a sheltered area could be used to safely continue operations. A plan requiring an alternate data type can also be invaluable should a piece of equipment break, particularly if a significant transit is necessary to reach the survey area.

2.5.1 Survey Scope

The scope of an OCS hydrographic survey will be categorized as basic hydrographic, navigable area, field examination, or special project. Survey requirements will vary according to this classification. The type of survey to be conducted and any special requirements will be identified in the Project Instructions.

In general, the requirements for hydrographic surveys develop as a result of policy decisions, product user reports or requests, national defense needs, and other demands. The type of specific hydrographic survey projects are created via an evaluation of known requirements and priorities. Survey limits are based on these requirements and priorities as well as an quantitative and qualitative measures of shipping and boating in an area, the adequacy of existing survey information in the area, the rate of change of the bathymetry, safety precautions and an assessment/weighting of benefit versus efficiency.

More information on project planning can be found in the Operations section of the Hydrographic Survey Division Headquarter Procedures Manual (currently in draft).

2.5.1.1 Basic Hydrographic Surveys

A basic hydrographic survey must be able to stand alone, without supplementation by any other survey. The basic survey must be adequate to supersede all prior surveys for charting purposes and meet all applicable survey requirements specified in HSSD.

2.5.1.2 Navigable Area Surveys

Navigable area surveys must meet the requirements of basic hydrographic surveys, but will have special survey limits defined in the Project Instructions. Typically for this type of survey, the limits have been restricted to omit areas that are not considered navigationally significant. Another scenario would be restricting the survey to primary shipping traffic areas. Assigned survey limits may require adjustment based on safety and field unit observations of local traffic patterns. Any significant survey limit adjustments shall be coordinated through the Chief of OPS.

The inshore limit of hydrography and feature verification for Navigable Area Surveys is the Navigable Area Limit Line (NALL), unless stated otherwise in the Project Instructions. This term has had different definitions and different interpretations therefore it is advised to review section 3.5.5 for more information.

2.5.1.3 Field Examinations

Field Examinations (FE) are item investigations or surveys that cover small areas of specific interest. These surveys may be assigned to prove/disprove the existence of reported dangers or obstructions, to provide data for harbor development, or to supplement prior surveys for construction of large-scale charts.

2.5.1.4 Special Projects

Special Projects are surveys typically performed for purposes other than creating nautical charts, such as habitat mapping, ocean exploration, or homeland security. The Project Instructions will define requirements for Special Projects.

Note: Depending upon the type of project, data acquired for Special Projects may be subject to additional security measures. Any required security practices will be defined in the Project Instructions. The field unit should use discretion when handling Special Project data and contact the Chief of OPS or Chief of NRB if data security requirements are in question.

2.5.1.5 Homeland Security Surveys

Homeland security surveys may be assigned in response to requests by the US Naval Oceanographic Office (NAVOCEANO) for hydrography to support Homeland Security in the nation's coastal waterways. These projects are typically 200% side scan sonar surveys conducted in accordance with NOS requirements for SSS data acquisition and processing with minor modifications. Specific criteria for homeland security surveys may be found in Appendix 2 (NAVMETOCCOMINST 3142A March 2007.pdf). The NAVOCEANO specification should be followed as closely as possible in conjunction with the OCS authorized deviations set forth in Appendix 2 (NAVMETOCCOMINST 3142A March 2007 - OCS Deviations.pdf). Any additional project specific requirements will be provided in the Project Instructions. In the event that it is not possible to adhere to the HLS specifications, Chief, HSD Operations Branch should be contacted for further guidance.

Special attention should be given to setting up survey plans and file structures when a survey area contains a region to be submitted for Homeland Security purposes. Careful advance planning will ensure that the relevant Homeland Security survey data and associated ancillary files will be easily extractable for submission to NAVOCEANO.

2.5.2 Object Detection Criteria

Unless otherwise specified by the Project Instructions, all data acquisition shall be conducted to meet object detection criteria as set forth in the HSSD; this may be accomplished with SSS, MBES, or a combination of the two. Object detection capabilities are dependent upon the acoustical characteristics of the sonar system. Vessel speed versus sonar pulse repetition rate (ping rate) must also be considered in order to meet coverage requirements in the along track direction. Standards set by OCS for object detection vary depending on sonar technology (e.g., side scan or multibeam). Requirements for each sonar type are discussed individually below.

2.5.2.1 Side Scan Sonar (SSS)

The HSSD states that side scan sonar systems shall be operated such that a 1 m^3object on the sea floor can be detected from acoustic shadow measurements. OCS has determined that this object detection criteria can be met by acquiring a minimum of 3 independent ensonifications (pings) per meter traveled in the along-track direction. This criterion can be met by regulating vessel speed based on sonar range scale. Longer operating ranges have slower pulse repetition rates, thus requiring that the vessel speed be slower to meet object detection requirements. Refer to sections 6.2.1 and 6.2.2 of the HSSD for further guidance on side scan object detection standards. Sonar ping rates should be defined in the operator's manual or the manufacturer's technical documentation.

2.5.2.2 Multibeam Echosounder (MBES)

Multibeam echosounder object detection criteria vary according to water depth. Adequate detection has been defined by OCS as 3.2 beam footprints, center-to-center, per 3 meters (in depths of 40 meters or less) or a distance equal to 10 percent of the depth (in depths greater than 40 meters). In the along track direction, this criterion can be met by regulating vessel speed based on sonar range scale, which directly affects ping rate. Since the size of MBES beam footprints will be greater as the angle from nadir increases, object detection capabilities should be calculated based on outer beams. Field personnel should refer to section 5.1.2 of the HSSD for further guidance on multibeam object detection standards. Sonar ping rates should be defined in the operator's manual or the manufacturer's technical documentation.

2.5.3 Survey Line Planning

Before creating a line plan, the Project Instructions should be reviewed for any required methodology, line spacing, or coverage requirements. Besides Letter Instruction requirements, factors such as general bathymetry, traffic patterns, shoreline features, currents, and prevailing weather and sea states should also be considered during line plan creation. New features discovered during operations may warrant additional adjustments to line plans as the survey progresses. It should be noted that survey limits are subject to revision based upon command decision and/or requirements for safe vessel operation. Any significant survey limit adjustments shall be coordinated through the Chief of HSD Operations Branch.

Safety should never be compromised for the sole purpose of following a line plan.

- Line plans used for data acquisition can be classified into the following categories:
- Mainscheme (MBES, SSS, or VBES)
- Holidays (MBES, SSS or VBES)
- Crosslines (MBES or VBES)
- Developments (MBES or VBES)
- Target Files
- Special Circumstances

Acquisition requirements vary depending upon data category and the type of equipment used. OCS recommends that field units standardize survey line numbering such that data classification can be determined based upon line number. For example, use the 100 number series for the first 100% of side scan sonar lines; the 200 number series for 200% side scan numbers; the 300 number series for side scan holidays lines; the 400 - 500 number series for mainscheme multibeam lines; the 600 - 800 number series for development data; and the 900 number series for crosslines. Specific line numbering standards have not been implemented by OCS; however, standardization within each field unit is strongly recommended.

Line plan requirements and guidelines for each data category are discussed in the following sections. Keep in mind that these guidelines are provided to help the field unit maximize survey efficiency, but they should not be followed at the expense of personnel and vessel safety.

2.5.3.1 Mainscheme

Mainscheme refers to the primary survey data that are systematically acquired to meet basic survey requirements. Mainscheme data are typically comprised of complete or object detection MBES data or 200% SSS imagery data acquired simultaneously with VBES bathymetry. However, in some circumstances variances such as a combination of complete multibeam and 100% side scan data may be preferred.

When planning mainscheme lines, special consideration should be given to junction areas. For surveys that are part of the same current project and from the same year, data overlap in junction areas shall be sufficient to ensure continuous coverage. To adjoin with a non-contemporary survey from a different year and possibly conducted by a different vessel, a 100-200 meter overlap of mainscheme data is required, unless the Project Instructions and provided project limits indicate otherwise.

2.5.3.1.1 Multibeam Echosounder (MBES) When planning mainscheme MBES lines, the hydrographer must consider object detection requirements, echosounder system, and water depth. If complete coverage is desired, line spacing will vary according to the effective swath width. The available swath width will vary between systems, but object detection requirements may require data filtering by swath angle or could even limit the types of sonars which may be used. Generally, lines should be oriented parallel to depth contours for consistent swath widths and line spacing. The following formula can be used as a general rule of thumb for determining swath width:

Available Swath Width = 2 x Water Depth x (tangent 1/2 swath angle)

The hydrographer should keep in mind that allowing for adequate data overlap when planning mainscheme lines can significantly reduce the number of holidays created during acquisition. Based on the above formula and collective OCS experience, mainscheme line spacing is commonly set at 3 x Water Depth to obtain complete coverage.

Additionally, the effects of the Cone of Silence (CoS) should be taken into consideration when planning line spacing. The Cone of Silence can reduce the ability to detect least depths of obstructions/features near the edge of the swath. Further information on the CoS may be found in Appendix 2 in Cone_of_Silence.pdf.

In special cases, partial MBES coverage may be used for mainscheme survey data. This type of coverage might be assigned if time is limited and existing survey data are fairly modern. In such cases, required line spacing will be noted in the Project Instructions. For further information on MBES requirements for OCS surveys, see section 5.1.2 of the HSSD.

2.5.3.1.2 Side Scan Sonar (SSS) Typically, two-hundred percent coverage is required when using SSS as a mainscheme survey technique. One hundred percent coverage is completed by acquiring data that meet the assigned object detection requirements over the entire survey area one time. This process is performed a second time to obtain two-hundred percent coverage. Side scan sonar data quality will, inherently, degrade both at nadir and at outer ranges. Because of this characteristic, line plans for the second hundred percent should be either offset or oriented differently than the first hundred percent. OCS recommends offsetting 200% lines by ½ of the line spacing for the first 100% coverage. If possible, SSS data should be acquired by running lines perpendicular to depth contours to avoid imagery distortion caused by slopes in the athwartships direction.

Note: Multibeam backscatter imagery, while often helpful during data processing and evaluation, is not considered equivalent to, or a replacement for, side scan sonar imagery. Side scan sonar provides low grazing-angle imagery that enables identification of features not visible in lower resolution, higher grazing angle MBES backscatter imagery.

The line spacing necessary to obtain 100% SSS coverage is dependent upon the effective range scale, achievable positional accuracy, and any positioning errors inherent to a towed system. A good rule of thumb to obtain complete coverage is to plan survey line spacing at 1.6 x Range Scale, allowing for an overlap of 40% of range scale (20% of the total swath) between adjacent swaths. Note: Range Scale refers to the athwartships distance ensonified on each side of the towfish. Thus, Range Scale equals one half of the total swath ensonified.

Generally, SSS range scale is chosen for maximum survey efficiency. The sonar should be maintained at an altitude of 8 - 20% of range scale during acquisition; thus, water depth will determine an upper range scale limit for a particular survey area. However, the hydrographer should also consider the system configuration and if a minimum sonar depth will be necessary to avoid water column disturbances such as propeller wash. Based on the chosen range scale's corresponding ping rate, vessel speed should be adjusted to ensure that object detection criteria are met (see 3.3.1). If a specific range scale is required for a survey, it will be indicated in the Project Instructions.

2.5.3.1.3 Vertical Beam Echosounder (VBES) Since complete coverage can not be efficiently completed using VBES alone, this will rarely be assigned as the sole method for acquiring mainscheme survey data. Typically, VBES systems will be used to provide correlating sounding data for SSS operations, define an inshore contour, or develop very shoal or foul areas where there is a high probability of damaging either a MBES or SSS system.

If VBES has been assigned as a stand-alone mainscheme data acquisition method, the required line spacing will be noted in the Project Instructions. If possible, VBES mainscheme data should be acquired by running lines perpendicular to depth contours. This practice assists the hydrographer in accurately identifying contour intervals. If extensive discrepancies are found between VBES sounding data and charted depths, the Chief of OPS or Chief of NRB should be contacted to determine if a more extensive survey is warranted.

2.5.3.2 Holidays

Holidays are defined as gaps in mainscheme data or areas where accuracy requirements have not been met. Holidays may be caused by various events, such as vessel maneuvering, survey equipment problems, unexpected shoals, or rejection of poor quality data during post-processing. Holiday line plans are typically developed to address these data gaps as mainscheme acquisition progresses, rather than at the end of mainscheme operations. This practice will minimize transit time required to revisit each area of the survey with a holiday and the time required to acquire, process, and manage additional sound speed profiles. If the field unit uses a real-time coverage map during mainscheme data acquisition, most holidays can be identified and addressed prior to ceasing operations that day, thus increasing survey efficiency.

2.5.3.3 Crosslines

Crossline data are used to identify any systematic data problems by comparing it to mainscheme data acquired at different times, water levels, and line azimuths. Separate vessels may also be used for crossline data acquisition to help identify any vessel to vessel system biases.

Ideally, crosslines should be acquired prior to mainscheme data, in areas of gently sloping bottom, and when water levels are as close to survey datum (MLLW) as practicable. Crossline data may not agree well with mainscheme soundings if acquired in areas of irregular submarine relief and/or if VBES systems are used. In rocky areas, large depth differences may occur over small horizontal distances, making a small positioning error appear to be a large depth error. This effect is often noted when using VBES systems due to the large beam footprint. In the case of VBES, a pinnacle recorded at the edge of a beam footprint would have a recorded position at the center of the beam, thus introducing a small positioning error that, again, could appear as a large depth discrepancy. Specific guidance for both vertical beam and multibeam crosslines is provided in the HSSD.

2.5.3.4 Developments

A development is performed to either obtain a least depth over a known point feature or further define an area-based feature such as a shoal. Typically, dense MBES data are acquired for developments, although multiple VBES lines may be more appropriate for defining very shoal area features due to the significant decrease of MBES efficiency in such depths. If a VBES system is used to determine the least depth on a point feature, several parallel lines should be run over the feature until the hydrographer is confident that the least depth is recorded. A third method for determining a feature’s least depth is by diver investigation. The process of using a diver least depth gauge is discussed in 3.2.5. For additional information on feature investigation, refer to 4.4.

Note: Conducting developments during high stages of tide will improve MBES efficiency and may also provide increased vessel safety by maximizing underkeel clearance. If development lines are created to be run during a specific tide range, the hydrographer must be certain to convey this information to the vessel crew that will be acquiring the data.

When developing point features, least depths should be acquired using the center region of the MBES swath, typically 45° or less off nadir. This section of the MBES swath will have less error due to refraction than the outer beams. It is recommended that, during development acquisition, a confidence swath be run in an orthogonal direction to the primary development lines. A common MBES development line plan may appear to be an assortment of “H” or “+” patterns over numerous features. Keep in mind that marine life will often congregate over prominent features such as wrecks and coral heads, sometimes making a least depth determination very difficult. In such cases, it may be beneficial to run the confidence swath at a different time than the primary development lines.

2.5.4 Survey Polygon Planning

As of the 2009 field season, most field units will be equipped with data acquisition software that allows the sonar operator and the coxswain to view a realtime coverage DTM of the data being acquired. As an alternative to line planning, which is most often redundant with this software capability, polygons that define areas to be covered are created by the sheet manager. While the entire area could just be covered with a continuous line, polygons provide the hydrographer with discreet sections to be covered assisting in better plans for survey timing and vessel efficiency. Most of the guidance that applies to line plans also applies to polygon planning. The data should still be acquired with the boat traveling parallel to the contours. Also, it is still important to consider traffic patterns, prevailing wind and weather conditions, currents, tides, obstructions, ATONS and water depths. As is the case with line plans, every person will come up with a different set of polygons, but keeping these points in mind will create more effective polygons in the long run:

- Polygon planning is a natural extension of line planning. In other words, you could take a full line plan and draw the outlines around similar "patches" of lines and you would have a pretty decent (although perhaps not ideal) polygon plan.
- The deeper the soundings where a polygon is drawn, the larger it should be. There is no need for a polygon that gets filled in with two passes. This is the same as the "larger spacing between deeper lines" concept. Thus, plan smaller polygons in shoaler areas and larger polygons in deep areas.
- Polygons should be planned such that the boat will be running offshore to nearshore. This is a safety tip! Creating separate offshore and onshore polygons (those that can be run at any time vs. those that need a specific tide window) is also helpful.
- There is no hard and fast rule for size limits, or polygon shape. In fact, avoid a cube shape. Make polygons longer in the dimension the boat should run, providing a clear indication to the coxswain and surveyor of the polygon's directionality. (If running N to S will be most efficient with the contours, make your polygon longer in the N to S dimension).
- If there is a MHW Buffer, a limit line that defines the shoal edge of the survey (survey to the 4 meter curve) or a NALL established during shoreline verification, do not plan polygons inshore of these limits unless there is a specific reason to do so.
- Think about what YOU would find natural on the boat! As an example, use a natural ledge or point of land as the "end" of one polygon and start of the next on the other side of it. Instead of the launch turning around a point of land, it should run a straighter polygon along one shore before curving around the point and driving along the next polygon.
- In a channel that could be filled in with one polygon (shore to shore), consider breaking it down into two polygons such that there is a straight edge in the middle of the channel. This provides the vessel with a straight baseline, and encourages running from offshore to nearshore.
- Set polygons up in such a way that turns are minimized and lines are of a manageable length for processing.
- Be aware of any possible sources of fresh water, or other factors that will affect the water column and make smaller polygons in these areas.

2.5.4.1 AWOIS Items

For all assigned AWOIS investigations, the entire search radius shall be investigated if possible, regardless of its position relative to the survey limits. Specific investigation methods considered adequate for an item's disproval will be noted in each AWOIS record. Often, AWOIS items can be investigated in conjunction with mainscheme data acquisition.

Note: If the entire search radius is not investigated, it is nearly impossible to disprove an AWOIS item.

2.5.4.2 Target Files

Target files refer to a collection of geographic positions designated for point data acquisition. These files are typically created when planning bottom sample locations, but may also be used to designate specific positions for acquiring other types of data. For example, the hydrographer may create a target file to show the specific position where a sound velocity profile is desired or specific locations of items to be developed.

2.5.4.2.1 Bottom Samples Samples of bottom sediment throughout the survey area shall be obtained and analyzed in accordance with the HSSD, if required by the Project Instructions. Per the HSSD, bottom samples are not required in depths greater than 100 meters. The following additional guidance for NOAA hydrographic field units applies to water depths of 100 meters or less.

Bottom sediment should be sampled and analyzed at intervals of 1200 meters or less in designated or potential anchorage areas and 2000 meters or less in all other areas. If these intervals can be met by sampling at the locations of currently charted bottom characteristics, those positions shall be used in order to verify current charting. If not, additional sampling locations shall be added as necessary to meet the required sampling intervals. Additional sampling locations should also be added, at the hydrographer’s discretion, based on observed vessel activities and/or significant variance of bottom characteristics identified in the survey data.

Ideally, a sediment sample analysis should be performed at the location of each charted bottom characteristic. However, if currently charted bottom characteristics are significantly closer together than the required sampling intervals noted above, the hydrographer may choose to perform a subset sampling routine. Subset sampling requires that samples be obtained at selected locations that are both positions of charted bottom characteristics and, as a group, meet the specified sampling intervals. However, a sample is not required at the location of every charted bottom characteristic. If the subset data agree well with charted characteristics, the Chief-of-Party may waive any requirements to obtain samples at the remaining charted bottom characteristic positions. If the subset sampling analyses do not agree well with charted bottom characteristics, then sediment samples should be obtained and analyzed at the position of each charted bottom characteristic.

Once bottom sample locations have been planned, it is recommended that a target file be prepared to ensure samples are obtained at each planned position.

2.5.4.3 Special Circumstances

2.5.4.3.1 Search Patterns In emergency or accident situations, NOAA field units may be involved with wreck, obstruction, or debris searches. When planning this type of operation, the direction of the search pattern should be oriented within 20° of the set of any significant current present in the survey area. This arrangement will minimize towfish offset from the planned tracks, increase position accuracy, and increase towfish stability by minimizing forces that are not aligned with the longitudinal axis of the towfish. However, tracks run in the same direction as a very strong current may result in an increased speed over ground, which could decrease object detection capabilities; thus, this parameter should be monitored if searching for small objects. If strong currents exist in the area and running search tracks in a pattern oriented normal to the current is unavoidable, the operations should be timed to coincide with periods of slack or minimum current, if possible.

2.5.4.3.2 Special Wreck Investigations If a hydrographic field unit discovers a potentially significant historic wreck site, or conducts a special wreck investigation through a contract from another NOAA program or a request from a NOAA Navigation Manager, the field unit should make an effort to ensonify the wreck site and associated debris field with each type of sonar system that is readily available. When conducting side scan sonar operations, run parallel tracks on either side of the wreck, so that both sides are imaged, as well as two additional tracks orthogonal to the site. The imagery and bathymetry data will provide clues to the wreck's status and identity, identify any obstructions, and provide researchers with an adequate baseline assessment with which to compare future surveys.

2.5.5 Survey Plan Finalization

Proposed survey acquisition plans should be reviewed by the FOO and/or Chief-of-Party and any necessary adjustments made. Once approved by the Chief-of-Party, the plan should be converted from the format generated by the GIS software used to design the plan to a format that can be read by the field unit's survey navigation software. Typically, acquisition plans will be designed using MapInfo software and converted into a Hypack line file (*.lnw) or Hypack target file (*.tgt) for vessel navigation. This specific conversion process can be accomplished using the Hydro_MI.mbx MapBasic tool, which will also report the number and the total mileage of the planned lines. Number and mileage statistics should be recorded and used to estimate the amount of time required to complete the survey. These estimations are critical to overall project planning.

2.5.6 Preparing the Survey Crew

A diligent Survey Manager will provide survey crew(s) with more than just a digital line (or area) plan for the day. Simply loading the line/area plan into acquisition software and verifying that it works a day prior to use can minimize problems encountered by the survey crew. As noted in 2.5, Line plans for alternate operational areas, as well as alternate data types can enable sustained productivity if weather degrades or a system malfunctions.

The Sheet Manager should also keep in mind that other members of the field unit will be less familiar with his/her survey, so additional information may be extremely useful during data acquisition. A plot depicting line plans, polygons, and/or shoreline files overlaid on the largest scale chart for the survey can be particularly helpful and is commonly referred to as a "boat sheet." Notes, such as uncharted hazards, lines planned for acquisition during high tide or slack current, and required range scales can also be indicated on a boat sheet. When performing developments, a contact description that can be correlated to each feature is invaluable for verifying that the item "found" during the development corresponds to the intended contact.

Chapter 3

Data Acquisition

> Plans are only good intentions unless they immediately degenerate into hard work. – Peter Drucker

3.1 Sensor Risk Management

NOAA field units deploy valuable oceanographic sensors in the water when conducting hydrographic surveys. The sensors are typically deployed in three ways: (1) mounted directly on the hull of the survey vessel, (2) suspended in the water by mounting them to a rigid retractable pole, or (3) towed via a cable. The utmost care should be taken to prevent the loss of a hydrographic sensor prior to its deployment. When not in use, the sensors should be stowed for transit. Safety devices designed to prevent the loss of a sensor should be checked and engaged before every deployment of the sensor. Devices designed to aid the recovery of a lost sensor should be used when available. The navigation and/or acquisition system should be running whenever the sensor is deployed. As soon as a loss is suspected or known, you should immediately mark the position where the suspected or known loss occurred and communicate the situation to the survey and navigation crew. If you are in safe water, go back to the position where you suspect the loss occurred.

3.2 Bathymetry Acquisition

NOAA hydrographic field units use a variety of echosounder systems to acquire bathymetry data. Multibeam echosounders (MBES) are preferred for their ability to efficiently acquire complete or object detection coverage datasets; however, vertical beam echosounders (VBES) are commonly used in conjunction with side scan sonar operations. Much of this section is dedicated to operating echosounder systems and recording sonar data using common software packages. However, lead lines, sounding poles, and diver least depth gauges are still occasionally used to acquire bathymetry and requirements for these are included in this section.

3.2.1 Lead Line Data

A lead line can be used to measure depths in areas too shallow for echosounders, to verify least depths over dangers to navigation or shoals, and to calibrate echosounders. Lead line soundings should be acquired at slack current, if possible, to ensure that readings are true vertical measurements of depth. All lead line soundings should be clearly identified as such in the survey records. The hydrographer shall also, at a minimum, record the lead line number, geographic position, and time of measurement for each sounding. Water level correctors must be applied to lead line data during post-processing.

3.2.2 Sounding Pole Data

Sounding poles can be used to acquire data in near shore areas where depths are less than 4 meters. Sounding poles should be carefully deployed so that a significant amount of sediment penetration does not occur and a true vertical measurement of depth is obtained. Each pole sounding should be clearly identified as such in the survey records. The hydrographer shall also, at a minimum, record the sounding pole number or identifier, geographic position, and time of measurement for each sounding. Water level corrections must be applied to sounding pole data during post-processing.

3.2.3 Vertical Beam Echosounder (VBES) Data

Vertical beam echosounder systems may vary among NOAA hydrographic field units. Most OCS systems are dual frequency, using both a high and a low frequency, with beamwidths between three and eight degrees for high frequency, larger for low frequency (20-30 degrees). Provided the magnitude of vessel roll and pitch is less than the sonar beamwidth, these attitude characteristics will have little effect on sounding accuracy and their application to VBES data is not required by OCS. However, to maintain data quality in sea states where vessel roll and pitch angles exceed sonar beam width, OCS recommends that an external sensor be used to record heave data for application during post-processing. If a heave sensor is not employed, the VBES system should be used only when conditions are favorable for minimizing heave bias and data must be scanned for heave artifacts during post-processing. If heave artifacts can be reliably interpreted, they shall be manually removed from the depth data. Data acquisition should be suspended if the heave signature exceeds 0.5 meters and a heave sensor is not being used.

Many VBES systems output calculated depth values rather than the two-way travel time of each sonar ping. To facilitate internal depth calculations, these types of VBES systems must be configured with an estimated value for the speed of sound through the water column. When necessary, hydrographic field units shall configure VBES systems using 1500 m/s, the standard estimate for the speed of sound in sea water. VBES data shall then be corrected using a full sound speed profile during post-processing.

Note: Sonar manufacturers often suggest applying real-time attitude, sound speed, and other corrections during data acquisition. It is OCS's standard policy to apply such data corrections during post-processing if possible.

The HYPACK MAX software package is commonly used by NOAA hydrographic field units to acquire VBES data. OCS guidelines for using HYPACK MAX with VBES systems are described below. Users should also refer to the HYPACK MAX User's Manual, which has been included on the Hydrosoft DVD. Field units equipped with alternate software or systems incompatible with HYPACK MAX should consult the appropriate user's manuals and/or contact the regional HSTP Field Support Liaison for guidance.

3.2.3.1 HYPACK MAX

HYPACK MAX is produced by HYPACK, Inc. (formerly Coastal Oceanographics). This software is compatible with most types of VBES systems and can also be used for MBES data acquisition, as discussed in section 3.2.4.1. In addition to recording bathymetry data, HYPACK MAX includes capabilities for completing the following tasks:

- Survey preparation and line planning.
- Precise survey line navigation.
- Recording of supporting sensor data such as position, heading, and attitude.
- GPS coordinated time-tagging of sonar and supporting data.
- Display of geo-referenced images as background files during acquisition.

3.2.3.1.1 System Setup To record, or "log," data using HYPACK MAX, a Project must first be created. Separate HYPACK MAX Projects are typically created either for each survey or for each data type to be acquired. Be certain to save each newly created Project with a unique name, or all changes will be lost when another Project is loaded. Critical steps for Project creation are described below. Once saved, Projects can be loaded and changed as necessary.

3.2.3.1.1.1 Device Setup For each Project the hydrographer should assign a default Device Setup that includes drivers and recording settings for each sensor. Since data formats can vary drastically and HYPACK MAX manages data for numerous sensors, it is critical that the correct Device Setup be loaded for each type of sensor being used. If a Project's default Device Setup is incorrect for the systems being used, a different Device Setup can be loaded after the Project has been opened. Although creating a Project for each survey seems well organized, having a Project for each data type may better ensure that the correct Device Setup is used for data acquisition if multiple configurations will be needed for a single survey. OCS recommends that master Device Setups for each system configuration be backed-up to a removable disk and maintained by the FOO or equivalent.

As a general rule, no offsets should be entered in the HYPACK MAX Device Setup. It is OCS's policy to record survey data in the most "raw" form possible, then apply corrections and offsets during post-processing. One exception to this rule is transducer offsets. Transducer offsets entered in HYPACK will not be applied to recorded data. However, they will affect the displayed data and may be desirable for precise line-steering, particularly if offsets are large as with a side-mounted system.

3.2.3.1.1.2 Geodesy Default geodesy parameters should be set for each Project. All OCS hydrographic survey data shall be acquired in the North American Datum of 1983 (NAD83). This is accomplished in HYPACK MAX by selecting the GRS80 ellipsoid and appropriate UTM zone.

3.2.3.1.1.3 Line and Background Files Planned survey line files and any associated background files, such as charts and limits, should be loaded for each Project. HYPACK MAX is capable of reading these files from any local computer directory as well as across a network. However, it is recommended that all Project files be stored within the local HYPACK MAX Project directory. This file management strategy is easily implemented by using the File > Add File and Copy option when initially loading Project files, which will automatically copy each file to the current HYPACK MAX Project directory.

3.2.3.1.2 Recording Data Prior to recording survey data in HYPACK MAX, certain critical system settings and operations should be verified. These quick system checks are highly recommended by OCS, as they can prevent errors that require extensive editing or complete reacquisition of data.

3.2.3.1.2.1 Time Synchronization Through the Kinematic.dll device driver, HYPACK MAX uses an internal timing algorithm called "Veritime" to time stamp data during acquisition. Veritime synchronizes the time recorded in the raw data to UTC time from the GPS system, and will also automatically reset the acquisition computer clock to UTC time. By default, Veritime will determine UTC time from the GPS receiver's NMEA0183 ZDA message. Thus, the hydrographer must ensure that this ZDA message is being output by the GPS unit. Note: HYPACK provides an option to "Sync clock on other sentences than ZDA" Unless a system is configured for Precise Timing, this option is not recommended by OCS and should not be used for OCS survey data without first contacting the regional HSTP Field Support Liaison. Time is a critical component of survey data, and it is recommended that the hydrographer periodically verify that time stamps are being applied correctly to logged data.

3.2.3.1.2.2 Devices Test Once all survey sensors are operating, the user should test that sensor data are being properly received by HYPACK MAX. By navigating through the HYPACK MAX Hardware program, the user can "Test All" devices. This function opens a new window for each sensor in the current Device Setup. Data strings being received by HYPACK MAX will be displayed for each device. Although data strings can be complex, the expected data from each sensor should be easily identifiable somewhere in the datagram. Two common problem indicators during this test are either no data or a string of gibberish being displayed. No data being displayed is often indicative of sensor or cable failure, while gibberish frequently means that the sensor output baud rate does not agree with the receiving baud rate setting in HYPACK MAX.

3.2.3.1.2.3 Logged Data Paths By default, HYPACK MAX will log survey line data under the active HYPACK Project directory in a folder named "Raw", and target files will be recorded to a file in the format mmddyyyy.tgt created in the Project directory. However, each field unit will have a standard directory structure to which data and targets should be logged. It is important for the user to check "Override Project Path" (in SURVEY mode under Options > Project Information) and select the appropriate folder for both survey line data and target file data prior to beginning daily data acquisition. Using this option, survey and target data may be logged anywhere on the local system or across a network.

Additional point data can be appended to a target file by pre-loading an existing target file. Pre-loading is accomplished in the primary HYPACK MAX window by copying files into the "Target Files" folder, a process similar to loading planned survey line files. Target files can also be loaded as Chart Files (background data) in SURVEY mode, but these targets will be simply displayed on the screen, i.e., it will not be possible to select a target and see a range and bearing to it for use in navigation.

3.2.3.1.2.4 File Extensions Unless otherwise specified, VBES data will be automatically recorded with the file extension *.raw. However, it is OCS standard policy to log HYPACK VBES data with a Day of Year (DOY) file extension. Note: HYPACK erroneously terms the DOY format as "Julian Day". In SURVEY mode, the "Julian Day as Extension" option should be chosen under the Options > Project Information menu to create files with DOY extensions.

3.2.4 Multibeam Echosounder Data

There are two common types of MBES systems, swath and sweep. Swath systems produce multiple acoustic beams from a single transducer, while sweep systems consist of an array of vertical beam transducers mounted on a boom. NOAA hydrographic field units typically use swath systems; thus, only swath types will be discussed in this manual. Swath MBES systems can be further classified into digital beamformers and interferometric systems. Regardless of type, all swath systems measure both the angle and two-way travel time of the acoustic signals. The frequency of the signal varies from system to system, typically ranging between 12 and 455 kHz. During each sonar ping, a projector transmits a swath of acoustic energy into the water. Reflected energy returns to the transducer, where it is detected by a hydrophone. The way in which the return signal is received is one of the main differences between digital beamformers and interferometric systems. Digital beamformers have a defined number of beams and a specific beam width for the hydrophone, whereas interferometric systems sample their receive beam across its length at varying intervals.

Many MBES systems are capable of recording acoustic backscatter data. Multibeam backscatter is intensity data that can be processed to create low resolution imagery. Backscatter is co-registered with the bathymetry data and is often used to assist with bathymetric data interpretation and post-processing. To optimize a system for backscatter data quality, refer to the manufacturer's documentation. However, the hydrographer should be cognizant that adjusting a MBES system to enhance backscatter data may detrimentally affect bathymetry data quality.

NOAA hydrographic field units have mounted MBES systems using a variety of methods, but these configurations can be classified into one of two basic types: hull-mounts and pole-mounts. Each type of sonar mount has inherent benefits and potential problems that should be considered during data acquisition.

A hull-mounted system is generally very stable and semi-permanent, producing data with minimal noise due to vibration. A hull-mounted configuration can be accomplished by notching the vessel keel and installing the sonar head along the keel line, attaching a mounting plate for the sonar head to the vessel hull, or cutting a box into the hull and creating a retractable mount for the sonar head. The flow of water along a vessel hull can create air bubbles, which may cause noise in a hull-mounted system. This potential problem should be considered when designing a hull-mount system. Note: The aforementioned retractable mounting system is essentially a hybrid of a hull-mount and a pole-mount. Benefits and drawbacks associated with each type of configuration should be considered when designing and installing such a system.

A pole-mounted system is often the quickest and least intrusive mounting configuration. In its simplest form, the sonar head is mounted to a large pole that can be pivoted into the water during data acquisition, then pivoted back out and secured to minimize drag during transits. A more complex pole-type mount may consist of a retractable hinged arm that is unfolded into the water for data acquisition. When using a pole-mounted system, it is critical that the sonar can be both reliably deployed to a repeatable position (with respect to the vessel reference frame) and adequately stabilized during data acquisition. Pins or guy-wires are often used to help with system stabilization. Noise due to vibration of the mounting pole at certain vessel speeds is a common problem with pole-mounted systems.

Auxiliary sensors are normally used for acquiring data to correct MBES soundings for vessel attitude, position, and sound speed. Time synchronization of all sensor inputs is critical when acquiring MBES data, and there are several methods which can be used to accomplish this. Many NOAA hydrographic field units use a method called Precise Timing to time stamp survey data at the time of acquisition (see 3.2.4.1.2). Data acquisition software packages typically include a process to automatically synchronize the acquisition computer clock to Coordinated Universal Time (UTC) provided by a GPS receiver. Data is then time tagged as it is received and logged by the computer. If possible, OCS recommends configuring MBES systems with Precise Timing, which will minimize data artifacts due to latency in serial and ethernet interfaces. If using a flat-faced MBES transducer array, it is also critical that sound speed be measured at the face of the transducer for beam forming and beam steering. For this type of system, a surface sound speed measuring instrument should be mounted at the sonar head, and its data input directly to the sonar processing unit.

The HYPACK MAX / HYSWEEP software package and ISIS software package are both commonly used by NOAA hydrographic field units to acquire MBES data. OCS guidelines for using both types of systems are described below. Users should also refer to the HYPACK MAX User's Manual and/or ISIS Sonar User Manual, both included on the Hydrosoft DVD. Field units equipped with alternate software or systems incompatible with these software packages should consult the appropriate user's manuals and/or contact the regional HSTP Field Support Liaison for guidance.

3.2.4.1 HYPACK MAX / HYSWEEP

HYSWEEP is an additional module available for the HYPACK MAX software package discussed in 3.2.3.1 of this manual. HYSWEEP enables the hydrographer to record both MBES and SSS data, and runs simultaneously with HYPACK MAX. The HYPACK MAX base program enables precise survey line navigation for MBES operations. Many of the procedures required for VBES data acquisition in HYPACK MAX also apply to MBES and SSS data acquisition using HYSWEEP.

Basic information for using the HYSWEEP software module is provided in this manual. For more detailed information about the HYSWEEP program refer to the HYSWEEP User's Manual. This manual has been included on the Hydrosoft DVD.

3.2.4.1.1 System Setup System setup for HYSWEEP consists of adding MBES system devices in the HYSWEEP Hardware configuration to enable communication with the sonar system and the HYPACK MAX parent program. Note: HYSWEEP software can not be used to manipulate the sonar system settings. Any sonar settings changes must be performed using the sonar manufacturer's software interface. The HYSWEEP Hardware menu is accessible through the HYPACK MAX Hardware menu. No vessel or hardware offsets should be entered in HYSWEEP, as it is OCS's policy to apply corrections and offsets to data during post-processing. Additional devices may also be added to the HYPACK MAX hardware configuration for displaying multibeam data (nadir depth and matrix data) in the HYPACK MAX survey window.

To record data using HYSWEEP, a Project must exist in HYPACK MAX. HYPACK MAX Project creation is discussed in 3.2.4.2.1. Be certain to save each newly created Project with a unique name, or all changes will be lost when another Project is loaded. HYSWEEP files will be recorded to the same directory selected in HYPACK MAX.

3.2.4.1.2 Recording Data Recording data using the HYSWEEP module of HYPACK MAX is nearly identical to logging data directly in HYPACK MAX, as described in section 3.2.3.1.2. Typically both programs are run simultaneously. Data logging can be controlled in either the HYPACK MAX or the HYSWEEP program using the same commands and keyboard shortcuts. The two survey programs will begin/end logging simultaneously when a record or stop recording command is given in either one.

For OCS hydrographic surveys, HYSWEEP data shall be logged in ASCII HSX (HYSWEEP Survey Extension) format. While logging data, the HYSWEEP main survey window should be used to monitor logging and device alarms. MBES or SSS data can be displayed and monitored in real-time using windows selected under the View menu. Range scales for depth and beam width are accessed under the View > Options menu, and must be set to the appropriate values according to expected water depth or data will not be displayed in the survey windows (though it will still be logged). Multibeam display options, quality control tests, coverage map settings, and heave, pitch, and roll correction options are also accessed under View > Options menu. Note: the option to “Apply Heave, Pitch, and Roll Corrections” is used for display purposes only, and will not affect the raw recorded data.

3.2.4.2 IsisSonar (ISIS)

IsisSonar software, produced by Triton Imaging, Inc. (formerly Triton Elics International, TEI), can be used to record data from a variety of sonar systems, including both MBES and SSS (see 3.3.1). In addition to recording raw sonar data, ISIS includes capabilities for completing the following tasks:

- Recording of supporting sensor data such as position, heading, and attitude.
- GPS-coordinated time-tagging of sonar and supporting data.
- Display of geo-referenced images as background files during acquisition.
- Support of Precise Timing for data time-tagging, in some MBES configurations.
- Survey preparation and line planning.
- Precise survey line navigation.
- Real-time coverage mapping for MBES and SSS data.

Precise Timing is a MBES system configuration that improves the timing correlation of sonar, attitude, and positioning data by applying a time stamp at the point of acquisition and retaining that time in the data recorded by ISIS, rather than applying a time tag as data are transmitted to the ISIS acquisition computer. A Precise Timing configuration may not be possible for all data acquisition systems. Thus far, it has only been implemented in systems consisting of Reson 81xx series multibeam sonars with 81-P processors, Applanix POS/MV position and attitude sensors, and ISIS software. Explicit guidance for configuring Reson + POS/MV + ISIS systems to use Precise Timing is included in Appendix 3 (Precise_Timing_Setup.pdf).

3.2.4.2.1 System Setup To record data using ISIS, the user must first identify in ISIS’ Record Setup menu the sonar system being used. Multiple ISIS configurations are often created on the same acquisition computer when more than one sonar system is used from a single platform. ISIS settings will vary according to the sensors being used for each configuration. Note: Be certain to save each separate ISIS configuration with a unique name, or all changes will be lost when another configuration is loaded. Use the following procedure to save multiple ISIS configurations:

- Make a copy of the existing ISIS configuration file (*.CFG) you want to save.
- Rename the copied file, preferably to something which describes the system setup.
- Make a copy of the ISIS shortcut icon on the acquisition computer’s desktop and rename the icon, preferably to something which describes the system setup.
- Change the copied icon’s target path to contain the renamed configuration file name as follows: “. . . \ISISSonar\v#.##\ISIS.exe /CFG=renamed_configuration_file_name.CFG.
- Start ISIS with this new icon to recall the renamed configuration file.
- To create another configuration, start ISIS with the original desktop shortcut, make appropriate configuration changes, and then save the configuration.

3.2.4.2.1.1 Device Setup Once the sonar system is designated, a serial port must be set up for each auxiliary device inputting data to ISIS. For each auxiliary device, the hydrographer must enter serial communication (COM) port settings and tell ISIS how to interpret the incoming data string. The data format can be identified using a predefined template or by creating a unique template from a variety of tokens explained in the ISIS Sonar User Manual. This manual has been included on the Hydrosoft DVD.

In some configurations, HYPACK MAX software is used simultaneously with ISIS for survey line navigation and to coordinate data logging. For this type of setup, HYPACK MAX will transmit a "Delph" serial data string to the ISIS computer. A long, and often confusing, user-defined template must be entered for this COM port so that ISIS will properly parse the transmitted data and allow HYPACK MAX to control recording. The field unit's SOPs and senior survey personnel should be consulted when configuring a Delph COM port in ISIS.

3.2.4.2.1.2 File Format The OCS standard file format for recording hydrographic survey data in ISIS is the Extended Triton Format (*.XTF). Under the File Format option of the Record Setup menu, the user should select the *.XTF file format option and any additional sonar-specific options per the unit's SOPs. Survey-specific file header notes should be entered in this menu as well.

3.2.4.2.1.3 TritonMap, TritonNav, and BathyPro Basic ISIS software can be upgraded with the TritonMap module to enable survey line planning, precise line steering, and real-time coverage mapping that can be used directly for survey navigation. TritonMap includes two sub-programs: TritonNav and BathyPro. TritonNav is used to perform survey line planning and precise line steering. BathyPro processes MBES or SSS data in real-time and generates a coverage map for display. Coverage mapping capabilities include both digital terrain models (DTM) for bathymetry and side scan mosaics for imagery. If using a real-time coverage map for survey navigation, it may be desirable to enter transducer offsets into the ISIS software. These offsets will not affect recorded data but will correct the displayed data so that they are properly geo-referenced and portray actual coverage obtained.

3.2.4.2.2 Recording Data Prior to recording survey data in ISIS, certain critical system settings and operations should be verified. These quick system checks are highly recommended by OCS, as they can prevent errors that require extensive editing or complete reacquisition of data.

3.2.4.2.2.1 Time Synchronization Depending upon system configuration, ISIS software will use one of two methods to time stamp survey data as it is recorded. For Precise Timing configurations, ISIS will apply to all survey data a UTC time tag recorded at the time of data acquisition for each sensor. If Precise Timing has not been implemented, ISIS will time stamp all sensor data with a UTC tag as it is transmitted to the acquisition computer. In this second case, UTC time is determined from one of several prioritized NMEA0183 strings received by the GPS system. ISIS will initially attempt to read UTC time from the GPS receiver's NMEA0183 $ZDA message. $ZDA is the OCS-recommended time source for non-Precise Timing configurations; thus, the hydrographer should ensure that this $ZDA message is being output by the GPS unit. The acquisition computer's clock will be synchronized to whichever source will be used to time stamp survey data. Time is a critical component of survey data, and it is recommended that the hydrographer periodically verify that time stamps are being applied correctly to logged data.

Note: ISIS can be configured to read time from other NMEA0183 strings via specific entries in the GPS com port's token string. The user should be certain not to unintentionally exclude the ZDA message by entering “NO ZDA” or “NO CLOCK” in the token string. Refer to the ISIS Sonar User’s Manual for further information on taken strings.

3.2.4.2.2.2 Devices Test Once all survey sensors are operating, the user should test that sensor data are being properly received by ISIS. By navigating through the ISIS Tools menu, the user can perform a COM Port Test. This test displays the serial data string being received over each COM port. Although data strings can be complex, the expected data from each sensor should be easily identifiable somewhere in the datagram. Two common problem indicators during this test are either no data or a string of gibberish being displayed. No data being displayed is often indicative of sensor or cable failure, while gibberish frequently means that the sensor output baud rate does not agree with the receiving baud rate setting in ISIS.

Note: Serial bathymetry data may be recorded in hexadecimal format, which should not be confused with gibberish.

3.2.4.2.2.3 Logged Data Paths The user should set the desired path for logged survey line data each day. This process will vary according to system configuration. If HYPACK MAX software is being used for survey line navigation, the data path is set within the ISIS “HYPACK DDE” window. If using TritonMap software, the data path should be set in the ISIS “Switch File” window.

3.2.4.2.2.4 Storage Capacity Depending upon the sonar system, extensive quantities of ISIS data may be acquired each day. The user should verify that adequate disk space is available prior to commencing data acquisition. If disk space is exceeded on the user selected drive, ISIS will automatically begin logging data to a file named Overflow#.xtf on the acquisition computer’s hard drive. Each time logging is started and stopped or the maximum file size is met, a sequential Overflow#.xtf file will be created. Thus, an unaware system operator could inadvertently record a significant number of data files which would require renaming.

3.2.4.2.2.5 Sonar Adjustment Depending upon the sonar system being used, ISIS may provide a Server menu. A Server menu will allow the user to manipulate many of the actual sonar settings through the ISIS software. Settings will vary according to system type and survey location. The field unit’s SOPs and/or senior survey personnel should be consulted for recommended sonar adjustments.

3.2.4.2.2.6 Data Monitoring ISIS software has been known to occasionally freeze and stop logging data. When monitoring an ISIS system during data acquisition, the hydrographer should be certain to verify that data is continually scrolling in the Waterfall window and that both navigation and attitude data values are being updated in the ISIS Parameter Display window. If using a Precise Timing configuration, the hydrographer should also verify that UTC time and all system data are being updated in the Sensor Inputs section of the Reson processor’s BITE screen.

3.2.4.3 Multibeam Backscatter Data

Acquire and submit multibeam backscatter data whenever feasible. Submit backscatter data in snippet mode rather than pseudo side-scan sonar mode.

3.2.5 Diver Least Depth Gauge (DLDG) Data

A Diver Least Depth Gauge is sometimes used by NOAA hydrographic field units to determine or verify the least depth of a feature. Depth is determined by comparing a pressure value at a feature's least depth to a surface pressure and correlating this difference to water depth based on the local water density. For more detailed DLDG information, refer to the document DLDG.pdf in Appendix 3.

Prior to conducting dive operations, the DLDG battery voltage should be checked and a watertight plug installed to cover the gauge's six-pin power connection. Additionally, OCS recommends that either a grease pencil or a diver's tablet be secured to the unit to record least depth pressures and feature information. A NOAA Dive Center-approved fastener is often used to secure the DLDG to the diver's buoyancy compensator.

At each dive site, a surface DLDG pressure must be recorded. OCS recommends taking a surface reading both before and after the dive, then averaging the two surface values for post-processing. Divers should survey the entire feature to identify the point of least depth. Once the least depth point is located, the DLDG should be placed level with this point and a pressure reading determined. Pressure values will vary with surface sea action, so a value eye averaged over a period of a few seconds should be recorded. A buoy marker should then be moved to the point of least depth so that a DGPS position can be obtained from the surface. If time permits and the item is complex, it is beneficial to record dimensions and make a quick sketch, noting the point of least depth. At the conclusion of the dive, a sound speed profile must be conducted in the vicinity using a Sea-Bird SEACAT profiler to determine local water density. Using a SEACAT system enables the DLDG pressures to be processed with Velocwin software. A Dive Investigation Report should be promptly filled out for each item investigated. A report form (Dive_Investigation_Report.pdf) is included in Appendix 3.

3.3 Imagery Acquisition

NOAA hydrographic field units use a variety of sonar systems to acquire imagery data. Side scan sonars (SSS) are preferred for their object detection capabilities; however, many MBES systems can record acoustic backscatter data. Although acoustic backscatter may assist with multibeam data processing and determination of seabed characteristics when planning bottom sample operations, it does not meet OCS object detection criteria for hydrographic surveys. Since side scan data meets the OCS imagery requirements, this section of the FPM is dedicated to operating side scan systems and recording SSS data using common software packages.

3.3.1 Side Scan Sonar (SSS) Data

Side scan sonar systems and configurations vary among NOAA hydrographic field units. Traditional SSS operations consist of a sonar body, or "towfish," which is towed behind a vessel via a cable and winch system. During operations, transducers located on each side of the towfish emit an acoustic signal that ensonifies a wide swath of seabed. The frequency of the signal varies from system to system, typically ranging between 100 and 500 kHz. Lower frequencies will increase the maximum range scale of a SSS, but imagery quality and resolution increases with higher frequencies. The amplitude of returning echoes from the seafloor are recorded and geo-referenced based on the return time series. The intensity of the SSS return signal will also be affected by the acoustic reflectivity of the sea floor. For example, rock and metal objects are better reflectors than sand or mud. If the seafloor is flat, the return signal will include amplitude values at regular intervals along the entire range scale. However, if a scour is present or an object is elevated from the sea floor, a portion of the return signal will be irregularly spaced in time. This interruption causes an acoustic shadow, or a lack of return signal, along a portion of the range scale. This basic side scan sonar theory of operation is illustrated in Figure 3.1.

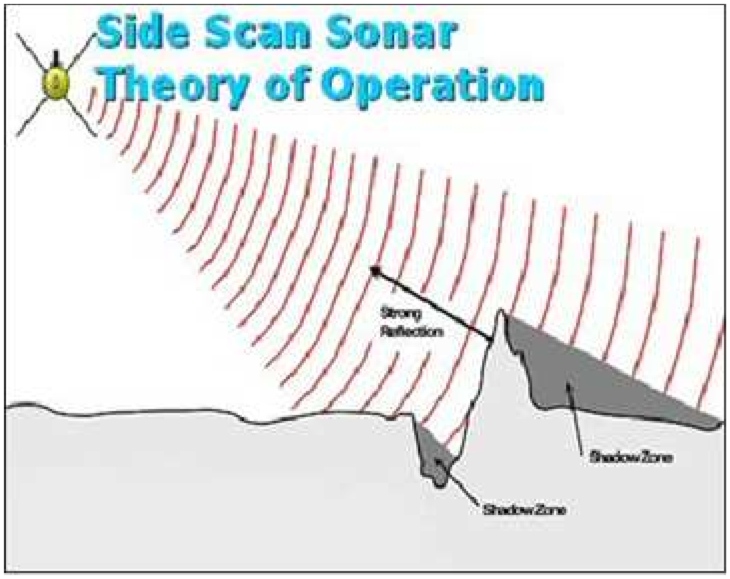

Figure 3.1: Basic side scan sonar theory of operation.

Side scan systems are typically towed at depth to increase sonar grazing angles and object detection capability. For optimum object detection, OCS recommends maintaining a towfish height of 8-20% of the operating range scale. NOAA's hydrographic field units effectively use both towed and hull-mounted SSS configurations. Each type of configuration has inherent benefits and potential problems that should be considered during data acquisition.

In towed configurations, towfish height is controlled by a combination of vessel speed and cable out. Although a towed configuration will maximize object detection abilities in various water depths, a certain amount of positioning error is inherent in any towed system. Because of this additional error source, SSS data are rarely used for final positioning of a feature. For hull-mounted configurations, position data are more accurate and operations can be conducted safely and effectively in shallow waters. However, since a hard-mounted system can not be lowered into the water column, sonar grazing angles will be directly affected by the water depth. As depth increases, object detection capabilities will decrease. It may not be possible to meet object detection criteria in deeper waters with a hull-mounted configuration.

Note: When operating a towed SSS system, towfish height should be carefully monitored. If a sonar grounding is imminent, increasing vessel speed will typically raise the towfish. This effect can be expected even if the towfish is equipped with a large depressor wing, although the result will be less dramatic.

The IsisSonar and SonarPro software packages are both commonly used by NOAA hydrographic field units to acquire SSS data. OCS guidelines for using both software packages are described below. Users should also refer to the ISIS Sonar User Manual and/or SonarPro Operation Manual, both of which have been included on the Hydrosoft DVD. Field units equipped with alternate software or systems incompatible with these software packages should consult the appropriate user's manuals and/or contact the regional HSTP Field Support Liaison for guidance.

3.3.1.1 IsisSonar (ISIS)

ISIS software can be used to record data from a variety of sonar systems, including both SSS and MBES. Refer to 3.2.4.2 for information pertaining to ISIS software capabilities.

3.3.1.1.1 System Setup The processes required to set up ISIS software for logging SSS and MBES data are similar and are detailed in 3.2.4.2.1. However, some of the actual sensors employed for data acquisition will vary. Separate ISIS configurations are often created on the same acquisition computer when more than one sonar system is used from a single platform, and the hydrographer must be certain that the correct configuration is used for data acquisition.

3.3.1.1.2 Recording Data Guidance for recording both SSS and MBES sonar data in ISIS software is similar. These procedures are discussed in 3.2.4.2.2. The daily system checks mentioned in 3.2.4.2.2 are also recommended prior to recording SSS data, as they can prevent errors that require extensive editing or complete reacquisition of data. The field unit's SOPs and/or senior survey personnel should be consulted for specific sonar adjustments and operation.

3.3.1.2 SonarPro

SonarPro, produced by Klein Associates (now a part of L-3 Communications), is a comprehensive software package compatible with the Klein 5000 Multi-beam and Klein 3000 Dual Frequency SSS systems. In addition to display and recording of SSS data, SonarPro includes a capability for managing sonar targets. This target management functionality can be particularly useful when performing emergency response surveys. Detailed information about SonarPro can be found in the SonarPro Operation Manual.

3.3.1.2.1 System Setup Since SonarPro is specifically designed to operate with Klein System 5000 and 3000 side scan sonars, system setup requirements are minimal. Klein System 5000 and 3000 sonars must be booted using a program called vxWorks. (OCS recommends that the boot process be monitored using a HyperTerminal connection between the acquisition computer and Klein TPU.) The vxWorks program will differ depending on which sonar system is being used (5000 or 3000), allowing SonarPro to automatically detect and configure for the type of system to which it is connecting.

Note: If using both 5000 and 3000 systems on the same acquisition system, be certain that the vxWorks file corresponding to the current system configuration is loaded in the “klein” directory before booting the sonar.

3.3.1.2.2 Recording Data Once the SSS has been booted, SonarPro software should be started (or if already running, select the towfish button from the main SonarPro display window to connect to the sonar). The user will be prompted to enter the Klein TPU Internet Protocol (IP) address to establish a connection between the acquisition computer and the sonar system. After creating a connection to the TPU, a Survey Wizard window will open that can be used to set up a data logging directory and target parameters. (The wizard may also be bypassed and accessed later from the main tool bar.) SonarPro will automatically display a Sonar Viewer window with SSS waterfall and towfish controls allowing the operator to start and stop the sonar from pinging. Once the operator is satisfied with the primary system setting choices, he/she should save the session by executing the Save State-Registry option under the Sessions menu. Saving State-Registry will cause SonarPro to open in this configuration the next time the software is opened.

3.3.1.2.2.1 Towfish Setup Towfish setup is accessed through the Towfish button in the Sonar Viewer window. OCS recommended setup values are listed in Table 3.1. When conducting standard OCS hydrographic surveys, the most efficient SSS range scale should be used, as described in 2.5.3.1.2. SonarPro will automatically select an optimal pulse length for the user defined range scale.

Sonar Setting	High Frequency	Low Frequency
Sonar Range	Set for maximum efficiency according to depth	Set for maximum efficiency according to depth
Pulse Length	Default	Default
Despeckle Sonar Image	Off	Off
Sonar Resolution	Normal	Normal
Side Scan System State	Default	Default
TPU Responder Control	Off	Off
Responder Frequency	28.5	28,5
Towfish Speed	Determine by GPS	Determine by GPS
Speed of Sound	150000 cm/s	150000 cm/s

Table 3.1: Recommended towfish setup.

3.3.1.2.2.2 Cable Out and Layback The Cable Out window is accessed either using the Cable Out button or from inside the Layback window by selecting the External Cable Out Source button. Cable out values can be entered manually or automatically through external cable out sources.

Note: When entering manual cable out, new values will not take effect until the user clicks the “Apply” button.

The cable out source and settings will vary depending on the system configuration. The operator should verify that Sonar Pro is reading the correct cable out values before logging data.

The hydrographer may want to enter vessel layback parameters (i.e., offsets from the navigation source to the sheave) so that SonarPro can generate accurate real-time positions for targets. Entering these offset values is important when investigating targets on the fly, such as during emergency response surveys. Vessel layback parameters are accessed through the Layback button in the SonarPro window. Save and apply the layback parameters by selecting the “Store Layback Parameters” button.

Note: Entering layback offset values will only affect the calculated positions of targets selected during acquisition. Logged vessel navigation will not be affected, and towfish position should be calculated during post-processing in CARIS.

3.3.1.2.2.3 Data Display Individual data display windows can be selected from the Window tab of the main SonarPro screen. If using a Klein 3000, separate SSS Sonar Viewer windows should be opened to display both low frequency (100 kHz) and high frequency (500 kHz) data. Since high frequencies provide higher resolution data, this data should be viewed in the primary display window. However, low frequency data should also be monitored as it may pick up features missed by the high frequency.

The user may want to display charts in SonarPro for navigation purposes. For the navigation window to work properly, the user must first copy the desired *.BSB and *.KAP raster chart files to the sub-folder designated for charts (commonly labeled Maptech) during SonarPro installation. It is recommended that only the charts needed for a given work area be maintained in the chart folder to minimize software loading time. Note: If attempting to display multiple charts, the charts must all have the same projection. Skewed raster charts will not display in SonarPro.

SonarPro provides two types of informational alarms, towfish altitude and towfish roll. It is strongly recommended that the towfish altitude alarm be set to visually and (if possible) audibly alert the user when this value falls below 5 meters. Towfish roll is a less critical value, and this alarm can be used at the hydrographer's discretion.

3.3.1.2.2.4 Data Logging SonarPro provides the option of logging SSS data in either *.XTF format or Klein's proprietary Sensor Data Format (*.SDF). OCS's standard policy is to log SonarPro data using the *.SDF format. The *.SDF format logs vessel position and cable out values, but not towfish position. A towfish position will be calculated during post-processing in CARIS. To begin logging *.SDF data, select the Record SDF button in the Sonar Data Recorder window. Maximum file size is set by specifying the maximum number of minutes per disk file in the data logging window. A maximum file size between 30 and 45 minutes is recommended based on field unit experience.

Note: If using HYPACK software for vessel navigation and logging bathymetry data, HYPACK and SonarPro must be started and stopped independently.

3.4 Position and Attitude Data

Position data should be determined as accurately as possible when conducting OCS hydrographic surveys. High-accuracy geographic positions are typically acquired using differentially-corrected GPS (DGPS) data. Position data quality must be periodically verified by performing confidence checks in accordance with section 3 of the HSSD.

Vessel attitude is also a critical component for acquiring high-accuracy survey data. Attitude is comprised of four separate types of motion: heave, pitch, roll, and yaw. Heave is the purely vertical component of vessel motion. Pitch is rotation of the vessel about its athwartships axis of motion. Roll is vessel motion about the fore-aft axis. Yaw, commonly referred to as vessel heading or gyro, is rotation about the vessel's vertical axis.

NOAA field units often measure position and attitude data using a single piece of equipment, the POS/MV (Position and Orientation System for Marine Vessels), manufactured by Applanix. Alternately, a combination of systems may be used to measure position, heading, and heave/pitch/roll individually.

3.4.1 Applanix POS/MV

The Applanix POS/MV is a GPS-aided Inertial Navigation System. It consists of two dual-frequency GPS receivers, an Inertial Measurement Unit (IMU), and a Processing unit. The IMU and GPS receivers are complementary sensors; data from one are used to filter and constrain errors from the other, resulting in high accuracy position and heading data. A GPS Azimuth Measurement Subsystem (GAMS) is used to aid the POS/MV in determining heading. GAMS heading aiding increases the system's achievable heading measurement accuracy, independent of latitude or vessel maneuvers. Additionally, the IMU senses linear acceleration and angular motion along the three major axes of the vessel to determine heave, pitch, and roll.

POS/MV Controller software allows the user to interact with the Processing unit for purposes such as performing calibrations and monitoring data accuracy. When acquiring data for OCS hydrographic surveys, POS/MV User Accuracy parameters shall be set such that the error values identified in Table 3.2 are not exceeded. If these User Accuracy parameters can not be met, the field unit shall contact the regional HSTP Field Support Liaison for guidance.

Data Parameter	Maximum Allowable Error
Attitude (Roll/Pitch)	0.05 degrees
Heading	0.05 degrees
Position	2.5 meters at 1 sigma
Velocity	1.0 m/s

Table 3.2: Maximum allowable POS/MV error for OCS surveys

The POS/MV Controller Program should be monitored continuously during survey data acquisition to ensure that the system is functioning properly and accuracy parameters are not exceeded. Occasionally, GAMS will experience difficulty determining heading parameters. Three common GAMS problems and corresponding solutions recommended by Applanix are described in Table 3.3.

POS/MV Symptom	Cause of Problem	Recommended Solution
POS/MV heading is correct within the User Accuracy parameters, but the "Invalid Installation Parameters" fault is red.	POS/MV has resolved the wrong set of ambiguities for its GAMS heading aiding	1. Select View > GAMS Solution and ensure PDOP is less than 3 and number of satellites is greater than 5. 2. Select Settings > Installation > GAMS Installation Parameters and click "Apply."
Heading Accuracy on the main Controller screen reads 55° for more than five minutes after powering on system.	POS/MV was not able to obtain an initial heading, a.k.a. "resolving its quadrant." This will most likely occur if POS/MV is powered on while the vessel is stationary.	1. Cycle POS/MV power. 2. Temporarily turn off DGPS corrections. 3. Power on POS/MV only while underway.
Heading does not match known vessel heading once quadrant is resolved. The "Invalid Installation Parameters" fault is red	POS/MV has resolved the wrong quadrant.	Cycle system to "Standby" and back to "Navigate".

Table 3.3: Common GAMS problems and recommended fixes.

Refer to the appropriate Applanix POS/MV User's Manual, included on the Hydrosoft DVD, for additional information on the POS/MV system.

3.4.1.1 Differential Correction

GPS accuracy is improved by applying correctors from land-based differential radiobeacons. The POS/MV system uses these differential corrections (RTCM SC-104 messages) when determining vessel position. However, the POS/MV system does not include a differential receiver.

A separate receiver must be serially integrated into the POS/MV configuration to obtain these messages. NOAA hydrographic field units often use Trimble DSM-212L or AGR-132 DGPS receivers to acquire differential corrections for POS/MV input.

NOAA hydrographic field units should use differential corrections from the United States Coast Guard (USCG) radiobeacon closest in distance to the survey area, if possible. If a beacon receiver is capable of monitoring more than one radiobeacon frequency, the unit should be set such that only one beacon station will be used. Allowing only one beacon frequency will prevent the receiver from switching to another beacon station without the operator's knowledge, which could cause erratic positioning and make determining the source of correctors difficult. It may be necessary to use an alternate radiobeacon station if the preferred beacon is not functioning properly. In such cases, the use of this secondary differential beacon should be noted in the data acquisition log.

3.4.1.1.1 Portable DGPS Reference Stations If differential correctors are not available from a USCG radiobeacon, a portable (previously known as a “Fly-Away”) DGPS reference station can be set up by a field unit. A DGPS Reference station (Figure 3.2) consists of an L1/L2 GPS receiver, a radio transmitter, a radio receiver, a VHF Antenna, tripods or light brackets, marine batteries, solar panels, a timer, and a laptop computer.

When choosing a site for DGPS reference station installation, the hydrographer should set it in a convenient place with good VHF line of sight to survey area and clear view of GPS satellites overhead (substantially clear sky all around from 10 degrees above horizon – see Chapter 3 appendices for more information). Consider in particular the following locations:

- setup over tidal bench mark: provides connection between tidal and GPS correctors.
- setup over other existing control mark: provides check with prior survey work
- least favorite: establish a new control mark (monumentation instructions available from NGS)

Find existing control marks using the "datasheets" link from National Geodetic Survey `http://geodesy.noaa.gov/`. If no accurate coordinates exist for your control mark, submit a survey data file to OPUS `http://geodesy.noaa.gov/OPUS`. For maximum accuracy, submit two each 6-hour files (see 3.5.3)and average the resultant coordinates (if OPUS results do not agree within 2cm, consult with NGS). Occasional repetition of this OPUS solution is recommended to provide confidence checks. Note, OPUS will soon allow archiving of geodetic control directly from the website. To allow this, record photos of the mark and a description of the mark location (see draft requirements here: `http://beta.ngs.noaa.gov/OPUS/`).

Instructions for setting up the beacon are provided with the kit and will not be provided here.

Check the entire beacon system by placing a roving receiver in a stable spot and tracking the position for 24 hours (see section 3.2.2. of the HSSD). If the resulting scatter plot (from the Trimble Pathfinder ProXRS or other receiver software) shows that more than 5% of positions exceed 5 meters from the average, this is an indication that there is a problem. Otherwise, save a screen shot of the scatter plot for your files.

Figure 3.2: Photograph of DGPS reference station setup.

3.4.1.2 True Heave

Heave data is calculated using a double integration of acceleration over a period of time. When recording heave in real-time, the calculation is performed using only past measurements of acceleration. An improved estimate of vessel low-frequency heave can be calculated by performing the integration over a time period centered on the time of interest, resulting in a “true heave” value (also referred to as “delayed heave”). “TrueHeave” is an option available with POS/MV V3 (firmware version 2.2 or greater) or with POS MV V4; additionally, a separate license and POS MV Controller v1.3.9.0 or greater is required. POS/MV TrueHeave is effective across long-period wave conditions (16- to 30-second period swell), whereas a real-time heave filter tends to exhibit its most notable artifacts in such conditions (>16 seconds).

Note: TrueHeave does not replace the need for dynamic draft corrections or water level corrections.

TrueHeave is logged using the POS/MV Controller software, via the Ethernet connection to the POS/MV PCS. TrueHeave data logging must be controlled separately from the primary data acquisition software, but it can be continuously recorded throughout the day. The TrueHeave filter requires a period of up to five (5) minutes after it has been enabled to initialize. The filter uses vertical acceleration data three (3) minutes past real time; hence, logging must continue for at least three (3) minutes past the ending time of survey line data acquisition. The time base used for TrueHeave data, "Heave Time 1", is user selectable in the POS/MV Controller software. For OCS hydrographic surveys, UTC (default) should be selected, not GPS time. Refer to the "TrueHeave Documentation 050603.pdf" included on the Hydrosoft DVD for more information regarding the theory, operation, and setup of TrueHeave.

TrueHeave files are applied to survey data during CARIS HIPS post-processing via the Load

True Heave tool, as discussed in section 4.2.3.3.

3.4.2 Alternate Positioning Equipment

3.4.2.1 Vessel-mounted DGPS Receivers

Numerous types of differential positioning systems are available on the open market, including terrestrial based DGPS receivers as well as satellite based DGPS receivers. NOAA hydrographic field units planning to acquire hydrographic survey data with a positioning system not identified in this manual should contact the regional HSTP Field Support Liaison for guidance and review the system's accuracies to confirm that survey specifications can be met. DGPS receivers that can automatically switch DGPS stations based on signal strength or distance from station should have these options disabled so that the receiver does not switch beacons while acquiring data. This can lead to horizontal shifts in data.

Note: Wide Area Augmentation System (WAAS) corrections can be received by most commercially available GPS units. WAAS relies heavily on a network of shore stations throughout the United States and is very accurate for shore-based and aviation applications. However, this accuracy may not apply to the marine environment.

WAAS corrections are not approved by OCS and shall not be used when acquiring data for OCS hydrographic surveys.

3.4.2.1.1 Global Satellite-Based Augmentation System (GSBAS) correction In situations where USCG DGPS correctors are not available and it is not feasible to set up a portable DGPS station (Fly Away), a field unit may choose to subscribe to a service such as NavCom Technologies StarFire network or C & C Technologies C-Nav network. These services utilize NASA's Jet Propulsion Laboratory's Real-Time GIPSY (RTG) Precise Point Positioning (PPP) technology to generate corrections and then broadcast them over L-Band communication satellites.

Field units wishing to utilize this method must activate their receiver's subscription. A 24 hour scatter plot over a known point must be conducted similar to the portable DGPS station. The recording interval may be set to a maximum of 1 minute. Performance data generated from the receiver's software must be recorded in conjunction with the scatter plot for comparison purposes. Distance from the nearest land-based observation station will affect the quality of the correctors you receive, so the 24 hour scatter plot should be conducted in the vicinity of the survey area. The field unit should remove the receiver from the vessel and conduct the scatter plot on land as the accuracy of the unit is on the order (or smaller) of the swing of the vessel on her mooring lines.

3.4.2.2 Portable GPS Units

In some situations, such as shoreline verification, it is more efficient for the field unit to position features using a portable GPS unit. Various models of portable GPS units are available on the open market. Portable GPS units shall meet the horizontal accuracy requirements as stated in Section 3 of the HSSD. These systems and survey techniques are discussed in 3.5.3 – GPS Horizontal and Vertical Positioning.

3.4.3 Alternate Heave/Pitch/Roll Sensors

3.4.3.1 TSS Dynamic Motion Sensor

Some NOAA hydrographic field units use a TSS Dynamic Motion Sensor (DMS-05) for measuring vessel heave, pitch, and roll. The DMS-05 includes an array of solid-state sensing elements that measure instantaneous linear accelerations and angular rates affecting the sensor. Heave is computed by double integration of the output from the linear accelerometer array. A filtering routine is performed after each integration, limiting the low frequency response of the system and allowing recovery from the erroneous effects of random noise and horizontal acceleration. The DMS-05 should typically be configured with a bandwidth period of 12 seconds to optimize the phase and amplitude of the vessel's vertical position. Velocity and heading information can be input to the DMS-05 from external devices to increase measurement accuracies.

3.4.4 Alternate Heading Sensors

3.4.4.1 Gyroscopic Compass

A gyroscopic (gyro) compass may be used to determine vessel heading. Gyro compasses use the effects of gravity and the Earth's rotation to produce a true north reference and may be mechanical by design or use fiber optic or laser technology. Ideally, a gyro compass should be installed on the centerline of the ship. When a gyro compass is used, the manufacturer's information should be reviewed carefully to determine if the system requires any user input such as vessel latitude and/or speed to achieve the specified heading accuracy and to identify approximately how much time is required for the system to slew when first powered up.

3.4.4.2 Course Over Ground (COG)

Vessel course over ground (COG) can be used to calculate a smoothed vessel heading. This technique will not be appropriate when acquiring all types of hydrographic data. Generally, any system hard mounted to the vessel will require an instantaneous heading. Since towed systems will not be affected by every slight motion of the vessel, they can typically use a calculated COG heading without detrimentally affecting the survey data. It may be possible to adjust the smoothing factor associated with COG heading data. Manipulating the smoothing factor would allow the user to adjust the frequency with which heading is calculated or how many position points are used to estimate the vessel course.

3.5 Ancillary Data

Two basic types of ancillary data are acquired in conjunction with OCS hydrographic surveys. The first type is used to correct sonar data and includes such measurements as sound speed and water levels, as well as horizontal and vertical control data. The second type consists of information that supports survey analyses beyond basic water depth measurements and object detection. Positions for aids to navigation (ATONs), bottom samples, shoreline determination, and Coast Pilot reviews are included in this second category. Both categories of data are important if the field unit is to provide a complete hydrographic survey.

3.5.1 Sound Speed Data

Sound speed data are used by NOAA hydrographic field units for multiple purposes. Primarily, sound speed profiles of the entire water column are used to correct sounding data for the effects of refraction and varying speed of sound through water. Water column profiles are also used when processing absolute pressure data obtained by a DLDG so that a water depth can be calculated. Additionally, flat arrays and to a lesser extent, the far off nadir beams in curved arrays (of MBES systems) require a continual real time input of sound speed data at the sonar head for proper beam forming and beam steering. It should be noted that using incorrect sound speed at the transducer face in beam steering can seriously impact the proper computation of launch/receive angle of all off-nadir beams on curved arrays.

When acquiring sound speed profiles to correct bathymetry, OCS recommends taking casts in the deepest portion of the survey area for which the profile will be applied. If data will be processed using Velocwin software, the sound velocity profile can be extended up to 30% of the cast's overall depth (in water depths less than 300 meters), providing more flexibility for cast locations. In water depths greater than 300 meters, the cast data will be extended to the maximum depth of historical data files loaded in the Velocwin program. The required frequency of casts will be dependent on the survey area, but OCS strongly recommends that a cast be performed at least every four hours during MBES data acquisition and once per week for VBES data. Casts may need to be taken several times a day in areas with dramatic tide cycles or subject to freshwater runoff or outfalls.

The Sea-Bird SEACAT conductivity, temperature, and depth profiler (CTD), Odom DigibarPro, and Brooke Ocean Moving Vessel Profiler (MVP) are commonly used by NOAA hydrographic field units to acquire sound speed data. Data acquisition is briefly discussed for each of these systems below. The user must be certain to record a DGPS position for each sound speed profile. Position information will be required by Velocwin software for data processing. If a system not discussed in this manual is being used to acquire sound speed data, the manufacturer's user's manual and the regional HSTP Field Support Liaison should be consulted to determine proper data acquisition procedures.

3.5.1.1 Sea-Bird SEACAT

The SEACAT is a portable, user-deployed, battery-operated instrument, typically housed in a protective cage. The SEACAT records water salinity, temperature, and pressure (i.e., depth) during deployment and retrieval. Sampling rate depends upon the CTD model being used, and is typically between 2-4 samples per second. These data are processed using NOAA's Velocwin software to calculate a sound speed profile for the water column. Prior to performing a cast, OCS recommends that the SEACAT memory be cleared by performing a Pre-Cast Setup and the instrument status be reviewed using Velocwin. If the SEACAT voltage is less than the following values listed below, the instrument batteries should be changed:

- SBE 19PLUS: 9.5 volts
- SBE 19: 7 volts

In both cases, the user is told to inspect the battery cut-off value in the status message. The battery should, at the very least, be one volt greater than the cut-off value.

The basic rule of thumb for conducting SEACAT casts is 3-2-1. The instrument should be turned on and allowed to sit on deck for 3 minutes while the sensors settle and form baseline measurements. Next, lower and hold the instrument just below the water's surface for 2 minutes, then deploy it at a rate of approximately 1 meter of depth per second. Conducting a cast too quickly may not provide enough data points for an accurate water column profile. Refer to the Sea-Bird SEACAT User's Manual, included on the Hydrosoft DVD, for additional operating instructions and to 1.5.2.3.

3.5.1.2 Odom DigibarPro

The DigibarPro Profiling Sound Velocimeter is a portable, user-deployed instrument consisting of a 15-inch, 4-pound probe attached by cable to a waterproof, hand-held control unit powered by internal batteries. The DigibarPro system includes a high frequency "sing-around" transducer and a reflector precisely spaced to facilitate measuring the speed of sound in water by continuously transmitting and receiving a signal across a known separation distance. The sing-around frequency and associated depth information are recorded at a rate of 10 samples per second. In many OCS applications, DigibarPro systems have been mounted to or near a MBES transducer to directly measure sound speed at the sonar face; however, some units deploy this instrument to obtain full water column profiles. Recorded DigibarPro sound speed profiles can be uploaded to a PC and processed using NOAA's Velocwin software. Refer to the DIGIBAR-PRO Operation Manual, included on the Hydrosoft DVD, for additional operating instructions.

3.5.1.3 Brooke Ocean Moving Vessel Profiler (MVP)

The Moving Vessel Profiler (MVP) is an automated winch system that deploys various payloads such as a free fall fish (FFF) that can be fitted with a sound speed sensor. The FFF is configured to “fly” at a specified depth until deployed by use of a “messenger” on the cable. Once at the depth limit, the winch is stopped manually and the drag forces on the FFF cause it to rise toward the surface due to the ship's forward motion while the slack cable is pulled in by the winch. For OCS operations, the messenger is set on the tow cable so that the FFF flies at survey transducer depth while the vessel is moving at survey speed. The FFF can either be user-deployed or deployed automatically by the computer at a defined time interval to a user-defined depth or a preset depth off bottom (typically 10 meters). The FFF is automatically recovered to transducer depth, ready to be deployed again. Because of the large number of casts that can be recorded by the MVP in a short time frame, it is convenient to batch process the sound velocity profiles using Velocwin.

Note: Sound velocity profiles created by the MVP must be processed using Velocwin version 8.76 or later.

Refer to the MVP Operation and Maintenance Manual and the MVP Software Manual, included on the Hydrosoft DVD, for additional information on this system and to 1.5.2.3.

3.5.2 Tide and Water Level Data

Tide and water level data are used by NOAA hydrographic field units to reduce bathymetric data to a local mean lower-low water (MLLW) “chart datum.” The hydrographer should be aware of the difference between tide data and water level data. Tides refer to the changes in water levels due to astronomical forces only. Tides are the only water level changes that can be scientifically predicted. Water level data refer to the actual (i.e., observed) changes in water level due to the combined effects of astronomical forces, wind, rain, freshwater runoff, and other meteorological events. It should be noted that predicted tides may differ significantly from actual water levels. Typically, inland water level stations are more susceptible to meteorological effects; thus, tide predictions for coastal water level stations can be expected to more accurately represent actual water levels than those for inland stations. Stations in relatively shallow water or with a small tidal range are also highly susceptible to meteorological effects, making water levels difficult to accurately predict.

3.5.2.1 Water Level Station Installation

Although CO-OPS will install, operate, and maintain control water level stations, hydrographic field units may be required to install subordinate stations. If an installation will be necessary for a project, it will be stated in the Project Instructions. In such cases, CO-OPS will provide a recommended general area for the gauge. The field unit is responsible for performing reconnaissance to determine if the recommended location is feasible. If the initial location is determined to be unsuitable, the field unit shall recommend an alternate location for CO-OPS approval. Gauge installation, operation, and removal shall be performed and documented in accordance with section 4 of the HSSD and section 5.2.3.2.4 of this manual. A copy of CO-OPS' Standing Project Instructions and Requirements For the Coastal Water Level Stations (Stndg_Instr_Coastal_WL_Stns.doc) and the CO-OPS Evaluation Criteria for Water Level Station Documentation Check-Off List (WL_Records_Checklist.doc) are included in Appendix 3.

3.5.2.2 Bench mark Recovery and Leveling

A bench mark is a fixed physical object or marker (monumentation) set for stability and used as a reference to the vertical and/or horizontal datums. Bench marks in the vicinity of a water level station are used as the reference for the local tidal datums derived from the water level data. The vertical relationship between the bench marks and the water level sensor or tide staff is established by differential leveling. NOAA Hydrographic field units will often be required to install and/or recover benchmarks and perform leveling operations for applicable water level stations at the start and end of data acquisition for a project. Existing bench mark descriptions and locations can be found under the Products menu of the CO-OPS website`http://www.tidesandcurrents.noaa.gov`.

Each water level station will have one bench mark, designated as the primary bench mark, that shall be leveled to on every run. Levels must be run between the water level sensor or tide staff and the required number of bench marks when the water level measurement station is installed, modified (e.g., water level sensor serviced, staff, or orifice replaced), for time series bracketing purposes, or prior to removal. Levels are required at least every six months during the station's operation, and are recommended after severe storms, hurricanes, earthquakes to document stability. Levels run at subordinate stations operated for less than one-year shall be at least third-order. Any requirements for higher order levels will be specified in the Project Instructions for the project. Bench mark installation and gauge leveling shall be performed and documented in accordance with section 4 of the HSSD.

Bracketing levels to an appropriate number of marks (five for subordinate stations) are required (a) if smooth tides are required inside of a 30 day time period. (b) if smooth tides are required 30 days or more prior to the planned removal of an applicable gauge(s), or (c)) after 6 months for subordinate stations collecting data for long term projects. (CO-OPS Specifications and Deliverables for Installation Operation and Removal of Water Level Stations, June 2007, Section 3.4)

3.5.2.2.1 Newiz 2.0 Software When performing leveling operations, NOAA field units may want to use the Newiz 2.0 software designed for use with a Personal Data Assistant (PDA). Newiz 2.0 is an in-house program that will check for thread errors and balance for each level shot. It will also verify that both the overall level run and each individual loop have closed within NOS tolerances. The Newiz 2.0 software will prompt the user to input data and produce an abstract that summarizes the level run. Although this software may be useful for field operations, Newiz 2.0 has not been officially approved by CO-OPS. Thus, hard copy records must be completed and submitted in accordance with section 4.6.1 of the HSSD. These records may be scanned to create a document for digital submission.

3.5.2.3 Water Level Data Retrieval

Typically, predicted tides or preliminary water level data are applied to soundings during initial post-processing. As verified or final water level data become available, the best quality data should be applied to bathymetry. Predicted tides will be provided on the Project CD/DVD. If an internet connection is available, field units can download six-minute preliminary water level data directly from the Products > Tides section of the CO-OPS website http://www.tidesandcurrents.noaa.gov within hours of data acquisition. Verified water level data should be available from the CO-OPS website within seven days if the station has been placed on the Hydro Hot List. If a station is not on the Hydro Hot List, verified data may take up to a month to be posted. If an internet connection is not available, field units should register with TideBot to receive water level data via email, as described in 3.5.2.3.2. Final water levels ("Smooth Tides") should be requested from CO-OPS, via a Request for Tides package that can be automatically generated using Pydro software. Guidance for submitting a Request for Tides is included in section 5.2.3.3.4.

3.5.2.3.1 Hydro Hot List CO-OPS maintains a list of water level stations that are currently providing data for OCS hydrographic surveys. This list is referred to as the "Hydro Hot List." If a water level station is on the Hydro Hot List, it is monitored by CO-OPS' Continuously Operating Real-Time Monitoring System (CORMS) and its data are given priority over other gauge data for office processing. Field units should notify CO-OPS by e-mailing: nos.coops.hpt@noaa.gov when data acquisition begins for a new survey so that the associated water level stations can be put on the Hydro Hot List. CO-OPS should also be advised when hydrographic survey data acquisition has been completed in an area so that stations can be removed from this list. Include the following CO-OPS personnel on correspondence pertaining to water level stations: Thomas Landon (Thomas.Landon@noaa.gov) for east coast stations and Manoj Samant (Manoj.Samant@noaa.gov) for west coast stations. Hydro Hot List can be found at http://tidesandcurrents.noaa.gov/hydro.shtml.

3.5.2.3.2 TideBot TideBot allows a field unit to initialize, change, and cancel water level data requests via web and email-based interfaces. Once configured, TideBot will automatically transmit preliminary six-minute water level data via email on a scheduled, recurring basis. To access TideBot through an email account, send an email to TideBot@noaa.gov with the word "help" as the subject. An email reply will be sent with instructions on how to subscribe to TideBot for time series data retrieval. TideBot subscriptions may also be added or removed through the CO-OPS website at http://www.tidesandcurrents.noaa.gov/tidebot.html.

3.5.2.3.3 fetchtides fetchtides is a procedural program which allows a user to retrieve tides data from a variety of sources including data e-mailed from tidebot, data in local files, and live data available through CO-OPS's Web Services. fetchtides then provides a mechanism to store the imported data locally and then combine multiple days worth of data into one CARIS readable tide file. For more information, see the fetchtides User Manual in the chapter 3 appendix.

3.5.3 GPS Horizontal and Vertical Positioning

NOAA hydrography frequently requires GPS positioning of features in the survey area independent of depth sounding operations. Field units have a range of equipment and techniques at their disposal to perform these measurements. While each survey will have slightly different requirements, typical operations are summarized in Table 3.4. The rationale for recommended or required durations of GPS observations is given in Table 3.5. Exact requirements can be found in the NOS Hydrographic Surveys Specifications and Deliverables or the relevant Project Instructions.

Accuracy Regime	Typical System	Typical Technique	Typical Applications
Sub-Meter horizontal and/or vertical	Dual-frequency receiver; constant height tripod	-Two 6 hour occupations (see Table 7) -OPUS post-processing with precise ephemeris	-Water level station geodetic benchmarks with vertical accuracy of 2 cm @ 95% confidence* -“Fly-Away” DGPS Reference Station Control Points Horizontal Accuracy: 3rd Order or better ($\leq$~1m @ 95% confidence) - Range Markers Horizontal: 0.1m @ 95% confidence
0.5-Meter horizontal	Single Frequency Portable GPS Receiver (Trimble ProXRS or similar)	-5 minutes of static L1 GPS data and differential correction	Ground Control Point Positioning by Navitation Response Teams for the National Geodetic Survey’s Remote Sensing Division. See RSD_GCP_Deliverables_ver3-5.pdf in the Chapter 3 appendix for guidelines on data acquisition.
1m @ 95% confidence Horizontal	Single Frequency Portable GPS Receiver (Trimble ProXRS or similar)	-10 to15 minutes of static occupation - Post-processed differential correction (Pathfinder Office utility or similar)	- Fixed ATONs (beacons or lights) - Mooring Facility features used for zero -visibility docking
5m @ 95% confidence Horizontal	Survey Vessel DGPS or Single Frequency Portable GPS Receiver (Trimble ProXRS or similar)	- DP with offset, short static occupation, or roving as appropriate	- Floating ATONs - General Shoreline Features

Table 3.4: Typical GPS positioning scenarios.

*Per requirements of the CO-OPS Users Guide for GPS Observations and NGS-58.

Recommended or Required Duration of Observation	Explanation	For Horizontal or Vertical positioning?
5 minutes	Due to advances in GPS technology, sub-meter horizontal positioning is now possible with an observation period of 5 minutes using the parameters found in table 3.6 below.	Horizontal only
15 minutes	Minimum recommended for OPUS-RS which may be a preferred alternative for much of your work. Unfortunately, it doesn't work in most remote locations or far offshore.	Horizontal and Vertical
2 hours	Minimum recommended for normal OPUS and is fine for your accuracy needs.	
4 hours	Minimum required for OPUS database (at least for now).	
6 hours	May be considered overkill, but preferred whenever practicable; e.g., if the system is set up to automatically record unattended and would be left set-up anyway.	
2nd observation	This is basic geodetic practice, but probably won't tell you much unless you really try for an independent observation with a new observer, independent antenna setup and measurement, etc.	

Table 3.5: Rationale for recommended or required durations of GPS observations.

It should be noted that independent observations are the key to survey confidence. If the hydrographer is using the same equipment, then it isn't true independence but it will give at least different satellites, different atmosphere, different ephemeris which could be an issue, at least theoretically. Whenever there is a convenient opportunity to collect more observations, it is recommended to do so and prove from repeated consistent OPUS results that you know where you are.

3.5.3.1 Sub-Meter GPS Positioning

3.5.3.1.1 Equipment Operations which require sub-meter accuracy measurements of horizontal and/or vertical position are generally accomplished with the following equipment:

- Dual Frequency (L1/L2) GPS receiver with internal logging, and appropriate batteries.
- L1/L2 ground plane GPS antenna.
- Antenna cable less than 10m in length. Shorter is better, but if you have or need longer (to protect receiver or observer), then use it. Cables should be treated gently to avoid lost or noisy signal which will decrease accuracy.
- Tripod or light bracket for antenna mounting (Fixed-height Tripod for high accuracy vertical measurements).

The following additional equipment is typically needed to install the GPS equipment:

- Magnetic Compass (for antenna orientation).
- Observation Log (see HorCon_VerCon_Obs_Log.pdf in Appendix 3 or http://www.ngs.noaa.gov/PROJECTS/GPSmanual/data.htm#obslog).
- Eyebolts, rock drill, rope/cable, etc. as required to secure antenna for long duration observation sessions.
- Digital Camera for site documentation.

3.5.3.1.2 Observations Sub-meter GPS positioning requires concurrent observations at one or more Continually Operating Reference Station (CORS) sites and/or other pre-existing control stations with accuracies of at least a 1st order triangulation (for sub-meter horizontal measurements) as well as vertical control for accurate vertical measurements (not A and B order control for sub-meter vertical measurements – A and B order control is for vertical only). For best results, the control station should be within 75km of the measurement site. Longer distances may be unavoidable in remote areas but may necessitate longer observation sessions to achieve the same order of accuracy. Both CORS sites and supplemental reference station information (A and B order control) is provided on the National Geodetic Survey CORS website: http://www.ngs.noaa.gov/CORS/.

To perform GPS observations, first assemble the tripod or light bracket (for fixed lighted ATONs) over the point for which a new position will be determined. Be certain that the antenna is plumb to the mark, oriented north, and level to the earth. Accurately measure the height of the antenna reference point.

Once the antenna has been properly set up connect the GPS receiver and check that it has the expected number of satellites in view and is computing a position. If performing a vertical position measurement on the geodetic benchmark of a water level station, ensure that the Vertical Dilution of Precision (VDOP) is less than 6.0 (as required by the CO-OPS Users Guide for GPS Observations and NGS-58, included in Appendix 3). At sites with poor satellite visibility, it may be necessary to use a GPS constellation prediction tool such as the Trimble Planning software to schedule sessions for best available satellite geometry.

Configure the GPS receiver to record GPS pseudo ranges for the appropriate amount of time to meet both accuracy specifications and post-processing requirements. There are several methods that can be used to post-process GPS data; however, NOAA hydrographic field units typically use NGS's Online Positioning User's Service (OPUS), which utilizes data from three nearby CORS sites and is available at http://www.ngs.noaa.gov/OPUS. To ensure that the data can be processed using OPUS, the following guidelines should be followed during data acquisition:

- Recording intervals on the GPS receiver(s) should be set to 15s or some multiple that coincides with the three nearest CORS site sampling rates. Sampling rates for each CORS site may differ and can be reviewed on the NGS CORS website.
- If using more than one receiver for an observation session, all of the receivers should be set to the same recording interval, since there must be common data between all stations.
- Observation times should be a minimum of two hours. For a strong OPUS solution, at least two hours of good data are needed. NGS recommends four hours of good data to achieve horizontal accuracy of 0.035 m. High-accuracy vertical positioning meeting CO-OPS requirements for geodetic benchmarks typically requires two six hour sessions, separated by at least 24 hours.
- OPUS can convert them to RINEX for most receivers. If not,before uploading GPS files to OPUS, convert them to RINEX2 format using the RINEX Conversion module included with the receiver manufacturer's software.

- Monitor the position and positional dilution of precision (PDOP) information displayed on the GPS receiver. PDOP is a unitless value that indicates the degree of position error in a measurement. Do not start logging data until PDOP is below six. Maintaining a PDOP less than six will help ensure that the observation file contains clean data that will not be rejected by quality control checks performed by OPUS. Note: Some systems will automatically begin logging data when powered on. In such cases, the user may need to manually stop a session once PDOP is below six, create a new session in the receiver, and start a new session so that data begin logging under a new file name. The first file can be easily deleted after downloading data.

An observation log for every setup shall be completed by the observer(s) on site. A blank HorCon/Vercon Observation Log is included in Appendix 3 (HorCon_VerCon_Obs_Log.pdf).

Additional detail on processing GPS Observations with OPUS can be found in 4.4.1.

3.5.3.2 Meter-level GPS Positioning

While horizontal position to 1m accuracy can be accomplished with the same equipment described above for higher accuracy measurements, it is often more efficient and convenient to utilize portable single frequency logging GPS receivers for this purpose. The Trimble ProXRS receiver with TSCe data collector or notebook PC is an example of this equipment commonly found in NOAA field unit inventories.

The Trimble Pathfinder ProXRS is a backpack GPS system which combines a GPS receiver and a beacon differential receiver. Although a single frequency (L1) GPS receiver, the ProXRS is capable of logging carrier phase data, which can be post processed to recover significantly improved positional accuracy. With the addition of the TSCe data collector, this system can be used to acquire static point or roving line data, and immediately assign object types and attributes based on the S-57 catalog. Static position accuracies of 1m or better can be attained when the system is used to occupy a point for a minimum of approximately 10 minutes, and the resulting data is post-processed with Trimble Pathfinder Office software.

3.5.3.2.1 System Software Two types of software are used to conduct operations with the Trimble Pathfinder unit. GPS Pathfinder Office software is used to create an initial configuration file for the ProXRS receiver and allows field personnel to post-process logged GPS data, including converting data into Shapefiles, which can be exported to Pydro. Trimble TerraSync software runs on the TSCe data collector or notebook computer, and is used to control the ProXRS receiver and log and attribute data. Refer to the TerraSync Operation Guide on the Hydrosoft DVD for specific information on this software.

3.5.3.2.2 System Configuration Prior to acquiring data with the Trimble Pathfinder system, a project and configuration file must be created. Both of these tasks should be completed using GPS Pathfinder Office software, although field adjustments can be made to the configuration file using TerraSync. Refer to the GPS Pathfinder Office Getting Started Guide, included on the Hydrosoft DVD, for specific details on how to create a project and configuration file. Numerous parameters must be entered in the configuration file. Those which have been recommended for use by OCS are listed in the table below.

Configuration Parameter	OCS Recommended Value
Log SuperCorrect Data	Yes
DOP Type	HDOP
HDOP Mask	2.5
PDOP Mask	6.0
SNR Mask	4
Elevation Mask*	10 degrees
RTK Static Precision- Horizontal	5.0 cm
RTK Static Precision - Vertical	5.0 cm
RTK Roving Precision- Horizontal	10.0 cm
RTK Roving Precision- Vertical	15.0 cm
RTCM Age Limit	20 s
Integrated Beacon Mode	Manual
Integrated Beacon Frequency	varies by area
Coordinate System	Latitude/Longitude
Datum Name	NAD83
Distance Units	Meters
Altitude Reference	HAE (height above ellipsoid)
Area Units	Square Meters

Table 3.6: Recommended Trimble Pathfinder Pro XRS configuration parameters.

*Per NOAA Technical Memorandum NOS NGS 58, for observation sessions less than 30 minutes, data collected below the 15° elevation mask angle should only be used if required to derive a successful GPS solution. OCS recommends acquiring data at an elevation mask of 10°, and increasing the elevation angle to 15° during post-processing. If data will not be post-processed, a mask of 15° should be used during acquisition. A copy of NOS NGS 58 is included in Appendix 3 (NGS-58.pdf).

3.5.3.2.3 Data Dictionary The Trimble Pathfinder Pro XRS uses a digital Data Dictionary to attribute data acquired with the unit. NOAA hydrographic field units shall use the Data Dictionary (Trimble_S57_DD_v2p1.ddf) in Appendix 3 as a base for acquiring S57 attributed data. The Data Dictionary should be loaded into TerraSync on the GPS datalogger or PC being used to record data. The base Data Dictionary list can be reordered to minimize menu scrolling during data acquisition and additional features added if necessary. However, this base file shall not be altered to remove any existing feature attributes. Consult the GPS Pathfinder Office Getting Started Guide on the Hydrosoft DVD for further information on editing the Data Dictionary.

3.5.3.2.4 Recording Data The Trimble Pathfinder Pro XRS can record position data as points, lines, and areas. Recording procedures will vary depending upon the position accuracy required. In general, a single geographic position with real-time differential correctors applied should be accurate within 2-5 meters and adequate for positioning features such as large shoreline features and bottom samples. The TerraSync acquisition software also includes options for applying offsets to a position which can not be directly accessed. Position offsets can be defined by a distance and bearing from a recorded point (distance/bearing), distances from two recorded points (distance/distance), bearings from two recorded points (bearing/bearing), distances from three recorded points (triple distance), or bearings from three recorded points (triple bearing). Distances and bearings can be either visually estimated or measured using a laser range finder and compass. Of these options, triple distance offsets measured with a laser range finder will provide the most accurate position, but this method may not always be feasible or necessary. The hydrographer should use the most efficient method of positioning that will meet data specifications.

When recording line data, the operator can configure the Trimble Pathfinder Pro XRS to record positions at specified time intervals. For positioning linear shoreline features such as piers, hydrographic field unit experience has shown a 1 second recording interval to be sufficient in most cases. A shorter interval may be necessary for more complex features, or multiple single points may more accurately portray a feature that requires indirect routes between corner points such as a cluttered pier. Refer to the GPS Pathfinder Systems User Guide, included on the Hydrosoft DVD, for detailed information on Trimble Pathfinder Pro XRS operating procedures.

Higher accuracy positioning can be obtained by static occupation of a site for multiple position measurements, and/or post-processing ProXRS data with the Trimble Pathfinder Office software's Differential Correction Utility. System setup, data acquisition, and data processing procedures for sub-meter positioning are detailed in "Trimble Pathfinder Office Post Processing Methods" in Appendix 4.

3.5.3.3 Special Instructions for Positioning Aids to Navigation (ATONs)

Positions and characteristics for all ATONs within a survey area shall be visually observed and compared to both the largest scale chart and current USCG Light List information during survey operations.

Note: Any ATON that is not serving its intended purpose, off-station, damaged, otherwise compromised, or uncharted and is determined by the field unit to present a hazard to navigation shall be immediately reported to the local USCG district.

NOAA's Update Service Branch (USB) will assign specific ATONs (fixed type only) which require positioning based on NOAA's Critical Corrections Database (CRIT) and/or USCG Integrated Aids to Navigation Information System (IATONIS) database records. Information for assigned ATONs will be provided on the Project CD/DVD. Additional ATONs may be positioned at the field unit's discretion if determined to be navigationally significant. Unless specific positioning methods or accuracies are assigned in the project Project Instructions, ATONs throughout the survey area shall be investigated, and positioned if necessary, in accordance with the following guidance:

- Assigned Charted Fixed ATONs – If possible, the field unit shall position each fixed ATON assigned by MCD. Assigned ATONs shall be positioned to an accuracy of less than one meter, at a 95% confidence level, unless otherwise specified. Many NOAA hydrographic field units meet this accuracy criteria by performing static GPS observations for a minimum a period of 10 to 15 minutes and post-processing position data using correctors from the nearest CORS station (e.g., using the Differential Correction utility in GPS Pathfinder Office software as described in 3.4.3.2). If obtaining this level of accuracy is unfeasible, but the field unit is able to acquire a higher quality position than that in the current database record, an upgraded position should be determined and included in the ATON Report (see 5.2.3.3.5). Acquisition methods and limitations should be described in the comments section for that ATON.

- Unassigned Charted Fixed ATONs – Charted fixed ATONs will not be assigned if a position accurate to less than one meter, at a 95% confidence level, has already been determined. If an unassigned fixed aid is observed to be significantly off station based on the largest scale chart, the hydrographer should review the USCG Local Notice to Mariners (LNM) for a discrepancy report on the aid. (Discrepancy reports are issued by the USCG when an ATON is known to be off station, but the agency has not yet been able to repair the aid. These reports are contained in Section 2 of each LNM.) If no discrepancy report has been published, the local USCG district should be contacted to determine whether the aid was compromised or intentionally relocated to serve its intended purpose. Following USCG confirmation that the aid is correctly positioned or has been properly relocated, the field unit should re-examine the aid. If it remains off station, this ATON should be positioned and reported as if it was an assigned aid.

- Uncharted Fixed ATONs – This category of ATON is typically comprised of privately maintained aids, and the field unit must determine if such an ATON is navigationally significant. If navigationally significant, a position should be acquired and the ATON reported as if it was assigned. For private aids reported, the field unit should specify both the apparent purpose and by whom the aid is maintained in the report.
- Charted Floating ATONs – The field unit shall visually verify positions and characteristics of charted floating ATONs during survey operations. If a floating aid is significantly off station with both the scale of the chart and scope of chain considered, the hydrographer should review the LNM for a discrepancy report on the aid. Note: Temporary positions of aids relocated to facilitate dredging, construction, or similar activities are typically not charted. If no discrepancy report has been published, the local USCG district should be contacted to determine if the aid was compromised or intentionally relocated to serve its intended purpose. Following USCG confirmation that the aid is correctly positioned or has been properly relocated, the field unit should re-examine the aid. If it remains off station, acquire a detached position (DP) for the ATON and report this item as if it was an assigned aid. Static GPS observations are not required when positioning floating aids.
- Uncharted Floating ATONs – The field unit shall determine if each uncharted floating ATON is navigationally significant (e.g., a mooring buoy or full-size private buoy, typically not a small private float). If navigationally significant, the field unit should acquire a DP for the ATON and report this item as if it was an assigned aid. Static GPS observations are not required when positioning floating aids.

For each survey, the field unit shall digitally submit an ATON Report to MCD as described in 5.2.3.3.5.

3.5.4 Bottom Samples

Bottom samples are typically obtained and analyzed in accordance with **??** of this manual and section 7.1 of the HSSD, and then discarded. Several sizes of bottom samplers are used in the NOAA hydrographic fleet ranging from small “clam shell” style samplers to larger Shipek style samplers. The field unit shall use the most appropriately sized bottom sampler for the vessel and conditions. If the bottom sampler is successfully deployed and tripped three times, yet no sediment sample is acquired, it can be assumed that the bottom is hard, and shall be recorded as SBDARE attribute NATQUA 10.hard for that sample location. If the bottom sampler is successfully deployed three times but will not trip, then the bottom type should be recorded as SBDARE attribute NATQUA 6.soft. If sediment samples are to be retained for future analysis, guidelines will be provided in the project Project Instructions.

3.5.5 Nearshore Hydrography and Shoreline

All modern NOAA hydrographic surveys are Navigable Area Surveys, unless explicitly stated otherwise in the Project Instructions. Navigable Area Surveys are basic hydrographic surveys with a restricted inshore limit of coverage.

The inshore limit of hydrography and feature verification for Navigable Area Surveys is the Navigable Area Limit Line (NALL), unless stated otherwise in the Project Instructions. By default, the NALL is defined as the offshore-most of the following:

1. 1. The 4-meter depth contour.
2. The line defined by the distance seaward from the MHW line which is equivalent to 0.8 millimeters at the scale of the largest scale nautical chart of the area (e.g., for a 1:80,000 scale chart, this line would fall 64 meters seaward of the MHW line).
3. The inshore limit of safe navigation for the survey vessel, as determined by the Chief-of-Party in consultation with his or her field personnel. If kelp, rocks, breakers, or other hazards make it unsafe to approach the coast to the limits specified in 1 and 2 above, the NALL shall be defined as the shoreward boundary of the area in which it is safe to survey.

In rare instances, the Chief-of-Party may determine that the NALL lies inshore of the limits defined in 1 and 2. For example, this could be the case in confined waters such as harbors or passes which are inshore of the NALL as defined above, but are regularly utilized by vessels depending on NOAA chart products for safe passage. It could also occur in deep water ports where modern bathymetry is required along wharf faces. In these cases, the Chief-of-Party shall consult with the Chief, HSD Operations Branch, prior to dedicating significant survey resources to these areas.

The hydrographer shall discuss in the Descriptive Report all areas where NALL definition deviated from the default criteria. Note that offshore surveys which do not approach the coast will end at their assigned survey limits.

The shoreline depicted on NOAA's nautical charts approximates the line where the average high tide, known as Mean High Water (MHW), intersects the coast and includes the attached cultural features that are exposed at MHW. In addition, nearshore natural and manmade features such as rocks, reefs, ledges, foul areas, aides to navigation, and mooring facilities are typically included in the colloquial definition of "shoreline." NGS Remote Sensing Division (RSD) is responsible for acquisition and compilation of shoreline data, which it provides directly to MCD for nautical chart updates. However, NOAA's hydrographic field parties may be tasked with verifying that shoreline details are adequately and accurately depicted in source datasets and the corresponding nautical charts.

Working near shore is inherently dangerous, and all field units are reminded that safety shall always be the primary consideration when conducting operations. Shoreline verification should not be attempted unless conditions are favorable. Even though an initial assessment is made by the Chief-of-Party, conditions at the actual survey area may be different or degrade as the day progresses. In such cases, the launch or skiff personnel should defer shoreline operations until conditions are favorable.

3.5.5.1 Source Shoreline Data

Unless otherwise specified in the project instructions, HSD Operations Branch will compile and provide a Composite Source File (CSF) and a Project Reference File (PRF) for all projects which require shoreline verification.

The composite source is an S-57 attributed dataset in .000 file format, compiled from all available ENC, RNC, Geographic Cells (RSD source shoreline), prior surveys, and contemporary LIDAR surveys. The source of each feature is indicated in its SORDAT and SORIND fields.

The project reference file is an S-57 attributed dataset in .000 file format containing features which are specifically targeted for further investigation, such as items from the Automated Wreck and Obstruction Information Service (AWOIS) database or those surveyed by LIDAR but not fully resolved.

Reference Features	S-57 Object	Description
Mean High Water buffer	CONVYR	.8mm buffer of the MHW line at the scale of the chart
AWOIS points	CRANES	AWOIS investigation items
AWOIS Radii	ACHBRT	AWOIS search radius
Survey Sheets	TESARE	outline of the survey sheet
Junction Surveys	TWRTPT	outline of junction survey
Survey Limit Line	TSELNE	survey limit line
LIDAR Investigations	BUAARE	placeholder indicating features recommended for field verification
LIDAR Junction Line	FNCLNE	line denoting extent of good LIDAR coverage

Table 3.7: Features contained in the Project Reference File from Operations Branch

3.5.5.2 Types of Shoreline Verification

Hydrographic Survey Project Instructions will specify which shoreline source documents are to be verified as well as the type of verification required, either “traditional” or “limited.” Shoreline source(s), chart scale(s), and local vessel traffic patterns are among the factors used in determining which method is appropriate for the survey area.

3.5.5.2.1 Traditional Verification Traditional shoreline verification is the most thorough and complete method, requiring full examination of all shoreline detail and features seaward of MHW. This technique is very rarely required, and is only necessary if the Project Instructions explicitly call for it. The hydrographer should examine all near shore detail and features seaward of the shoreline (MHW line) originating from composite source documents, NGS-verified remote sensing shoreline data, prior hydrographic surveys, and nautical charts. All features shall be verified, changed, or disproved, provided the operations can be conducted safely. Features located near the shoreline or some accurately plotted reference point may be verified by visual inspection. Navigation Response Teams (NRTs) should refer to the additional chart evaluation information provided in the Chapter 3 Appendices.

3.5.5.2.2 Limited Verification Typically, a limited verification will be assigned for OCS hydrographic surveys. When conducting limited shoreline verification, the hydrographer shall examine all features seaward of the Navigable Area Limit Line, in accordance with the following direction:

- All ENC, RNC, Geographic Cells, and contemporary LIDAR features on the composite source and seaward of the NALL should be verified or disproved. If a feature is found within 20 meters (This 20m tolerance does not apply to fixed ATONs specifically assigned for updated positions. See 3.5.3.3 for additional guidance on these features.) of the composite source position, a revised field position is not required . Heights/depths of all features seaward of the NALL should be determined by the best means available given the sea conditions at the time of the survey.
- Newly discovered features seaward of the NALL should be properly positioned with a corresponding height/depth.
- Features that have any linear dimension greater than 0.5mm by 0.65mm at the scale of the largest scale nautical chart of the area should be treated as area features and delineated appropriately. Features with lesser linear dimensions should be positioned and attributed as point features.

- Prior survey features within the Composite Source are for reference only. There is no requirement for the hydrographer to address prior survey features in the Descriptive Report.

It may be necessary to position, verify, or disprove some features inshore of the NALL, if they are both navigationally significant and safe to approach. Examples of features which might meet this standard include:

- Aids to Navigation
- Natural or manmade features sufficiently conspicuous to be an obvious navigational landmark (e.g., piers, pilings, or very large and isolated boulders or outcroppings)

Note: "Navigationally significant" is not easily and absolutely defined. As such, it makes up part of the “art” of hydrography vice the more easily quantifiable “science” aspect of the profession. Navigational significance depends on location, proximity to shore and/or other features and the marine traffic patterns/usage in the area. Ideally the person making the determination of navigational significance will be one who has extensive experience utilizing NOAA/NOS charts for navigation and can convey that perspective to the persons conducting the field survey work. This is typically the NOAA vessel Commanding Officer (Chief-of-Party) or Field Operations Officer, Hydrographer-in-Charge, or the contractor’s Lead Hydrographer.

Limited shoreline verification should be scheduled for daylight periods when the tide is within 0.5m of Mean Lower-Low Water (chart datum).

3.5.5.3 Conducting Shoreline Verification

Shoreline verification operations should be scheduled for daylight periods when the tide is less than 0.5m above Mean Lower-low Water (chart datum). To maximize the shoreline “window”, it is usually advantageous to plan for shoreline operations during spring tides when the extreme range allows for longer low water periods each day. In some cases, ideal water level conditions may not be available while the field unit is in the project area. In these cases, the Chief-of-Party should request further instructions from the Chief, HSD Operations Branch. Shoreline verification should be performed prior to main scheme bathymetric data acquisition in nearshore areas to ensure that submerged hazards have been identified to the full extent possible before launches with protruding transducers operate in the area.

Shoreline verification is typically conducted from a small, maneuverable survey vessel such as a skiff or jet-drive survey launch. The vessel should be equipped with survey-grade GPS and vertical beam echosounder interfaced to an appropriate data acquisition computer and software. Multi-beam echosounder equipped launches are not ideal for shoreline verification because of the increased risk of damage to hull-mounted transducers when operating in unsurveyed nearshore areas.

The vessel’s data acquisition software should be loaded with the composite source and other applicable files (ENC, RNC, and Project Reference File). In addition, it is often helpful to print a large “boat sheet” of the composite source on a large format printer. This is useful for orientation and quickly recording field observations.

A common and effective method for conducting shoreline verification is to run a VBES survey line parallel to shore, observing exposed features. In the case of Limited Shoreline Verification, this survey line should approximate the NALL, allowing the hydrographers to focus most of their attention offshore of the vessel. This approximate NALL can be used later to assist in planning the inshore extent of bathymetry. As features meeting the criteria given in 3.5.5.2 are encountered, the survey vessel should break off from following the NALL, investigate the features as required, and return to following the NALL.

Note that not all features require or even warrant investigation at low water. To maximize efficient use of low water windows, it may be best to skip these features on the initial pass, and return at a higher stage of tide. In extreme cases, it may be possible and advantageous to acquire complete MBES coverage of features which are exposed at low water.

3.5.5.4 Recording Shoreline Data

When performing shoreline verification, be certain to acquire sufficient data for a cartographer to accurately portray the shoreline on a chart. It is generally better to collect too much data than not enough; however, the hydrographer should not waste extensive amounts of time defining details that are clearly not pertinent to safe navigation. Point features are generally positioned using Detached Positions with a range and bearing from the survey launch, or by direct occupation with a portable GPS system. Line features or the extents of areas can be bounded by recording data as the launch passes as close as possible to the feature, taking DPs at the extents of the feature, or using a roving portable GPS to walk the extents ashore. In all cases, it may be prudent to take written notes on log sheets and/or the boat sheet in addition to recording data digitally.

Accuracy requirements for point positions depend on the type of feature being located. If the feature is a wharf or pier potentially to be used for zero-visibility docking, the horizontal position error should be 1.0 meter or less. For features not critical to zero-visibility navigation or docking, accuracy for all points should meet the minimum horizontal position accuracy requirement set forth in the HSSD. The method of positioning a feature to the required accuracy is typically left to the discretion of the hydrographer, subject to the guidance in 3.5.3.

When recording line data, positions are logged at regular intervals small enough to facilitate a "connect the dots" drawing of the area. For example, consider a new marina that is neither charted nor apparent on the composite source shoreline file. The associated piers can easily be positioned by walking along the edges of each while acquiring line data. Another option would be to start and stop the line at each of the feature’s corners so that a single point is logged at each corner. This allows the hydrographer to step around objects and debris when walking between points without logging the indirect path taken between the points. With this method, the resulting line data will generally be cleaner and more accurately represent the feature. Line data is a valuable tool for accurately delineating curved or irregular features. OCS recommends that line data used to define such features be acquired with a data collection interval of one second.

All data should be acquired with S-57 attribution collected at the time of acquisition. While many S-57 object types and attributes are self-explanatory. The hydrographer should consult the S-57 catalog and Volume 3 of the NOAA Nautical Chart Manual (ENC encoding guidelines) for guidance. Additional clarification for field units is offered in the Field Encoding Guide included in Appendix 3.

Shoreline features can be classified in four ways: verified, changed/modified, disproved, or new. Methodology for making each of these determinations is described in the following sections. Each feature should be thoroughly documented based on the type of determination made. Often a photograph can provide the best documentation for shoreline features. Photographs should be obtained from a vantage point that allows the cartographer to see the feature in context. Annotations digitized on the photograph, such as a north arrow and the location where a position was acquired, can be very valuable during office processing. If necessary, multiple photographs can be taken for one feature.

3.5.5.4.1 Verifications Features depicted on the shoreline source seaward of the NALL should be “verified”. If a feature’s position agrees with the composite source, it shall be considered verified. If a feature is located in a non-navigable area, a visual verification is acceptable. If necessary, ranges and bearings can be estimated from a safe location to assist with the verification process.

3.5.5.4.2 Changes If a shoreline feature has been found, but not exactly as depicted on the composite source, it should be documented as a change. For example, the extents of an area charted as "foul" may have changed since acquisition of the source data and would require adjustment. Shoreline changes shall be supported by position or bathymetry data and thoroughly described in the Descriptive Report. For cultural features, it may also be possible to obtain engineering drawings from local authorities. This type of information can be invaluable if a facility is under construction at the time of survey.

3.5.5.4.3 Disprovals To disprove a feature, the hydrographer must establish with a high degree of confidence that the feature does not exist at or near the composite source position. A feature is typically disproved using various search methods. Search methods for disprovals are based upon the extent and nature of the feature, the water depth, and the bottom composition. Search methods include, but are not limited to, visual, SSS, MBES, VBES, leadline, sounding pole, and diver investigations. Disprovals shall be thoroughly documented and include the method of search used, length of search time, water visibility, presence of kelp, eddies, or riffles, and any other pertinent information that supports the disproval.

A feature may also be disproved by providing official documentation that the item has been removed. Documentation for this type of disproval should meet the following minimum criteria:

- The authority providing documentation must have had direct involvement in the removal or verification of removal of the feature. Such authorities include the U.S. Army Corps of Engineers, dredging or construction companies, harbor masters, salvage companies, private hydrographic survey companies, etc.
- The authority providing documentation must be identified by name, address, e-mail address, and phone number so that contact can be established if further information is required.
- Documentation provided must be complete and sufficient to disprove the item.

Thoroughly documented telephone conversations or interviews with authoritative sources can also be used for feature disproval. Documentation should include the contact's name, address, email address, telephone number, and affiliation with the feature being disproved.

3.5.5.4.4 New Features If a shoreline feature has been verified to exist, but is not depicted on the source data or chart, it should be documented as a new feature. New features shall be supported by position or bathymetry data and thoroughly described in the Descriptive Report. It is recommended that digital photographs of new features be included with the descriptions. For cultural features, it may also be possible to obtain engineering drawings from local authorities to include with the feature documentation.

3.5.6 Coast Pilot Data

A field verification of Coast Pilot information, referred to as a Coast Pilot Review, shall be conducted for each assigned survey area. Additionally, information relating to the general operations area (e.g., areas frequently transited and facilities utilized during inports) should be reviewed and verified or updated to whatever extent practicable. Coast Pilot information provided on the Project CD/DVD should be reviewed prior to the start of data acquisition in each area and verified or revised as indicated below during subsequent field operations. Coast Pilot revisions or verifications shall be documented as follows and submitted in accordance with section 5.2.3.2.5:

- Make a digital copy of the Coast Pilot sections provided on the Project CD/DVD. Name this new file <source file name>_rev<revision date MM_YYYY>. For example, if the source file was named "CP2-05-34Ed-pages 323-356.rtf", the new file would be named "CP2-05-34Ed-pages 323-356_rev08_2005.rtf". Make all revisions to this copied file and retain the original for reference purposes.
- Deletions to the existing text shall be shown as strikethroughs.
- Recommended revisions, including any new information that would be beneficial to the mariner, shall be shown in red text.
- Existing text that has been reviewed and verified to be correct during field unit operations shall be changed to green text.
- Existing text that could not be verified or refuted during operations shall remain in black.

If possible, any pertinent Coast Pilot corrections should be obtained on-line at `http://nauticalcharts.noaa.gov/nsd/cpdownload.htm` and applied to the digital file provided prior to submission of the review.

3.5.6.1 Performing a Coast Pilot Review

When determining what information is pertinent for the Coast Pilot, the size, type, and number of vessels using each waterway must be taken into account. The requirements of the deep-draft navigator, yachtsman, and fisherman must all be kept in mind. Allowance must also be made for the thoroughness with which the region has been surveyed and charted. If the surveys of the area are incomplete, if the harbor charts are on too small a scale, or if the harbor has grown in importance, more detail will be required in the Coast Pilot. If possible, digital photographs should be submitted for significant Coast Pilot features in accordance with 3.5.6.2.

If additional information is necessary to address a Coast Pilot item, a wide variety of locally knowledgeable people can be used. However, information from outside sources should be verified by the reviewer. The source of the report should be given so that the report's value may be weighed against conflicting information that may be received by NOAA's Marine Chart Division. The following is a list of the principal organizations and officials who can be interviewed for the purpose of obtaining local information:

- Coast Guard stations and other aids to navigation units, buoy tenders and other cutters, patrol craft, and Marine Safety Offices
- Corps of Engineers district offices or other Federal field offices such as Customs Service
- Pilot associations, port authorities, harbormasters, and harbor police
- Other NOAA field parties operating in the area
- Operators of repair yards and marine service stations
- Captains of towboats, ferries, and coastwise vessels operating in the area
- Individuals very familiar with the area such as fishermen and longtime residents

- ◦ Yacht clubs

The following sections describe categories of information that should be addressed during a Coast Pilot Review. The majority of this information is best obtained during field operations and is thus considered a part of data acquisition.

3.5.6.1.1 Aids to Navigation Every effort should be made to ensure that aids to navigation referenced in the Coast Pilot are correctly identified and in agreement with both the chart and the Light List. Information regarding significant new aids to navigation (e.g., buoys/lights marking specific dangers to navigation) should be added.

3.5.6.1.2 Anchorages Attempt to obtain information on both charted and uncharted anchorage areas. The adequacy and accuracy of anchorage information in the Coast Pilot should be checked, and new reliable information should be added when possible. Anchorage information is one of the most difficult types of information to obtain and check, since it must come from actual anchoring experience. Good judgment must be exercised by field personnel in obtaining such information. A particular location is not a good anchorage simply because someone has anchored there.

3.5.6.1.3 Bridges Note bridges that are in the process of renovation (to the extent that type of bridge, vertical clearance, horizontal clearance, or other description normally mentioned in the Coast Pilot is affected), bridges that have been newly constructed, and/or bridges that have been removed in whole or in part. Confirm proper names of bridges as included in the Coast Pilot or shown on the charts. Obtain new names as appropriate. Confirm or obtain VHF radio frequencies/channels monitored, hailing protocols used by local traffic and telephone contacts related to bridge operations, if applicable.

3.5.6.1.4 Channels Text referring to privately maintained channels and basins, natural channels, and federally maintained channels within the assigned survey area should be reviewed and updated as necessary.

3.5.6.1.5 Dangers to Navigation Review and update as necessary any Coast Pilot text addressing charted rocks, shoals, reefs, wrecks, piles, snags, and other objects dangerous to navigation within the survey area.

3.5.6.1.6 Depths and Sounding Data Once present survey soundings have been processed and compared to charted depths, any Coast Pilot text referencing specific depths within the survey area should be reviewed and updated as necessary. Note: The hydrographer should be certain that final water level correctors have been applied to sounding data prior to reporting specific depths in the Coast Pilot Review.

If new depth information is received for an area outside of the assigned survey, but can not be verified by approved NOAA hydrographic survey methods, this information can be included in the Coast Pilot as “reported.” Reported information should be avoided unless deemed critical for safe navigation. If reported information is used, it must be qualified as such, giving the date and the source of information. Reported depths are published in the Coast Pilot as shown in the following example: "In June 2004, the channel had a reported controlling depth of 3 feet."

3.5.6.1.7 Ferries, Cable Ferries, and Pontoon Bridges Report the locations of new ferry terminals and routes and/or the abandonment of old ones. If applicable, include information about VHF radio frequencies monitored, hailing protocol, and telephone contacts.

Cable ferries and pontoon bridges pose a potential hazard to mariners. Obtain detailed information on their operations. Information regarding operational peculiarities of any other moveable bridges encountered should be included.

3.5.6.1.8 Landmarks Landmarks shall be inspected from seaward insofar as practicable. New landmarks considered to be significant for vessel navigation should be positioned with DGPS, if possible. Describe each landmark, including position, height, color and any other distinctive features that will aid in identification. Give the shape of objects that may not be generally recognized by the name alone, such as "the large white dish of the charted radiotelescope."

3.5.6.1.9 Locks, Canals, and Hurricane Gates Operational peculiarities of locks, canals, hurricane gates, and other navigation projects should be noted. Include information about traffic signals, VHF radio frequencies/channels monitored, hailing protocol, and telephone contacts, if applicable.

3.5.6.1.10 Overhead Cables Make note of overhead cables that are not charted and/or not mentioned in the Coast Pilot. Attempt to ascertain the following about the owner of the new cable: name of the company, address, telephone number, and name of a cognizant individual in the company. This information is necessary in order to obtain copies of the cable permits from the local District Engineer staff of the Corps of Engineers.

3.5.6.1.11 Major Deep Draft Ports Coast Pilot information pertaining to major ports, shipping terminals, and wharves within the survey area should be reviewed and confirmed to whatever extent practicable via sounding data and reconnaissance during survey operations. Particular attention should be paid to depth information stated in the text.

If at all possible, the local pilot association should be contacted. Pilotage information is one of the most important items in the Coast Pilot. Pilots should be requested to read the pilotage section in the Coast Pilot and point out any errors and/or new information that should be added. Be sure to address where vessels are boarded or anchored for quarantine, and whether inspections are made by any U.S. Government agency.

Additional information, such as low altitude oblique photographs, may be obtained from a variety of sources such as the local port authority, harbormaster, harbor police, and customs, immigration, public health, and agriculture officials at the port. Information on repair facilities can be obtained from shipyards and boatyards. Local towboat companies are often a good source of information, not only regarding the size and type of tugs available, but also for other information such as local peculiarities of winds and currents, the routes followed by tugs and barges, etc.

3.5.6.1.12 Small Deep Draft Ports Coast Pilot information pertaining to smaller deep-draft ports, shipping terminals, and wharves within the survey area should be reviewed and confirmed to whatever extent practicable via sounding data and reconnaissance during survey operations. Particular attention should be paid to depth information stated in the text. Although small deep-draft ports do not typically have large port authority staffs, additional information may be available from the port’s general manager.

3.5.6.1.13 Small Craft Harbors Coast Pilot information pertaining to small craft harbors within the survey area should be reviewed and confirmed to whatever extent practicable via sounding data and reconnaissance during survey operations. Additional information may be available by contacting either the harbormaster or harbor patrol personnel, as well as operators of towboats, boatyards, marinas, and state and federal agencies. Local yachtsmen and fishermen can be consulted when appropriate.

3.5.6.1.14 Radar and Radio Information If possible, obtain information on the best radar targets and the approximate maximum range at which they can be positively identified and used. The VHF radio frequencies/channels used in port areas for different types of communications between various private and public concerns should be ascertained. Where a radio watch is maintained by pilots, harbormasters, bridge tenders, lockmasters, and other parties significant to the mariner, confirm guarding schedules, VHF radio frequencies, hailing protocol, and telephone contacts, if applicable.

3.5.6.1.15 Shoreline Changes Coast Pilot information pertaining to shoreline within the survey area should be reviewed and confirmed to whatever extent practicable via sounding data and reconnaissance during survey operations. Note condition, additions, and deletions of wharves, piers, and other waterfront structures. If a pier or other shoreline structure has been removed, note whether piles or ruins remain as a navigational hazard. Assume the existence of submerged ruins unless there is contrary evidence. Also report significant shoreline changes, whether caused by dredging and/or filling or by natural events.

If Coast Pilot information pertaining to shoreline outside of the survey area (e.g., areas frequently transited or facilities utilized during inports) can be verified or updated during survey operations, this information should be addressed in the Coast Pilot Review.

3.5.6.1.16 Wrecks If numerous wrecks are found to exist in a specific location, an attempt should be made to ascertain the causes from survey data and/or local sources. If a specific hazard is determined, suitable highlighting of the situation should be verified or added in the Coast Pilot.

In addition to the above categories of information, any anomalous conditions that may affect safe navigation should be addressed.

3.5.6.2 Digital Photographs

When possible, digital photographs portraying significant Coast Pilot features should be acquired. Sea level photos should be taken from seaward, from as high a vantage point as possible and close enough so that principal landmarks can be identified. Photos taken successively from 2 miles out or less, typically upon entering or departing a harbor, may be useful in identifying the harbor approach or specific landmarks. If a single photo will not adequately cover the view of a harbor with sufficient detail, a panoramic series of photos can be submitted.

Digital photos submitted to the Coast Pilot Branch may be included in subsequent editions of the publication. To ensure photographs are of sufficient quality for publication, the following criteria should be met:

- The camera should have a resolution capability of 4 megapixels or better.
- A digital zoom feature should not be used. A camera with minimum optical zoom capability from wide angle (35mm) to a mild zoom (out to 105mm) is recommended. (Ideally, the

camera would accept lenses of different focal lengths, such as wide angle, normal, and zoom.) • Photographs should be taken using an ISO setting of 100 (preferred) or less, but in no case higher than 200.

- Shutter speed should be set to at least 1/100th of a second.
- The photograph should be taken using a pixel setting of approximately 2300 x 1700 or better.
- TIFF (*.tif) format or JPG (*.jpg) format is preferred for submission. Use of any other format should be cleared by the Coast Pilot Branch. If the JPG format is used, select “JPG (EXIF)” if that choice is given. EXIF is a standard metadata format that embeds information about the camera and its settings such as focal length, shutter speed, lighting condition, and other valuable information about the photograph into the file.

3.5.7 Electronic Navigational Chart (ENC) Verification

Verifications of ENC data are primarily performed by the NRTs. If ENC verification is required in conjunction with a standard NOAA hydrographic survey, it will be stated in the Project Instructions. Information regarding ENC shoreline and offshore features is given below.

3.5.7.1 ENC Shoreline Features

3.5.7.1.1 Aids to Navigation Unless specifically assigned, aids to navigation to be located are left to the discretion of the hydrographer. Range lights, channel lights, and major pier lights are priorities and should be positioned using static GPS whenever possible, unless an acceptable (Third-order, Class I or higher) published position is available. Other federally maintained aids such as day beacons and buoys, as well as private maintained aids may be located using hydrographic positioning methods. Refer to section 7.2 of the NOS Hydrographic Surveys Specifications and Deliverables manual for further guidance.

3.5.7.1.2 Structures On features directly affecting vessel docking, obtain one-meter accuracy DGPS positions on all critical points. Other points on the same feature may be surveyed to five-meter accuracy and/or derived from the imagery/shoreline files, provided they are accurate to five meters or less. All other structures may be surveyed to five-meter accuracy. Enter all relevant information; i.e., name, status, condition, etc., in the “Remarks” column.

3.5.7.1.3 Works in Progress Determine the status of construction for the identified marine facility or other chartable shoreline construction. Obtain as-built plan drawings if possible. When as-built drawings are obtained, ensure that they have a coordinate system on them. If they don’t, the NRT should obtain reference positions for the drawings using a GIS data collection and data maintenance system. Use the “Remarks” column to report the name, status, condition, or other relevant information.

3.5.7.1.4 ENC Offshore Features

3.5.7.1.4.1 Bridges The appropriate NSD Navigation Manager will attempt to get as-built drawings for project area bridges before the NRT arrives. If as-built drawings have been supplied, then the NRT will position the ends or other identifiable points of the bridge to provide geo-reference points for the drawing.

When no drawings are supplied and no DGPS interference is experienced, one-meter accuracy DGPS positions are required, to delineate clearances between bridge pier fenders facing commercial vessel traffic. Bridge pier fender points not facing commercial vessel traffic may be surveyed to five-meter accuracy depending on the relative importance to be determined by the hydrographer. When acquiring data points around obstructions such as bridges, differential correctors from the USCG beacons should be used. The Trimble Pathfinder Pro XRS has multi-path rejection technology that works best when using USCG correctors. Use the “Remarks” column in MapInfo Final Field Sheet table to report the name, status, condition, or other relevant information.

When a drawing is not available and DGPS interference is experienced, then the NRT will attempt to obtain positions over the supports that separate the commercial channel. NRB will not acquire positions on bridge fenders where the bridge structure causes DGPS interference.

3.5.7.1.4.2 Channel Depths Where applicable, inquire with facility owners/managers about the status of privately maintained channels to update charted notations. Provide documentation in the Descriptive Report or Chart Letter and submit diagrams or survey copies when possible. In some cases (at the discretion of the Team Leader) a survey of the channel will be required to obtain the current operating depths.

Chapter 4

Data Processing and Analysis

> Things should be made as simple as possible, but not any simpler. –Albert Einstein

The purpose of this chapter is to provide the information necessary to “clean,” finalize, and analyze data for OCS hydrographic surveys. The following types of data are each addressed separately in this chapter, although many aspects of processing and analysis for these data are intertwined:

- Bathymetry (VBES and MBES data)
- Imagery (SSS data)
- Features (bathymetry and imagery contacts, detached positions, AWOIS items, geographic positions)

4.1 Preparation for Data Processing

Data processing for OCS hydrographic survey data is typically performed using CARIS HIPS and SIPS software. HIPS tools are used to process bathymetry data, and SIPS tools are used with imagery data. To begin processing data in CARIS HIPS and SIPS, a “Project” must be created. A CARIS Project consists of a data filing system, structured according to a tree of project/vessel/day/line (PVDL) folders, where “vessel” refers to a particular vessel configuration file, known as a HIPS Vessel File (HVF).

The HVF establishes, in HIPS and SIPS, the relationship between survey sensors as logged by the acquisition software. The HVF must reflect any corrections or compensation of logged sensor data performed during acquisition – note the emphasis on the word logged. It is common for data acquisition software packages to have the ability to display sensor data (e.g., depths) in an entirely different form than that which is actually stored in the logged dataset. Additionally, some sonar systems require, or perform in a superior fashion, if real-time corrections (e.g., refraction) are used. Any real-time corrections included in the logged data must be accounted for when creating the HVF. The HVF also includes information essential for estimating sounding measurement errors (see 4.2.3.6). Depth and position errors will be introduced if data are processed using an incorrect HVF.

Proper setup of HVFs is critical for accurate survey data, and this process is usually completed under the direction of senior survey personnel. These files are typically created at the beginning of a field season, but they will need to be amended if configurations change. Guidelines for creating an HVF are described in section 4.1.1. Refer to the CARIS HIPS and SIPS User's Manual, included on the Hydrosoft DVD, for addition information.

Once HVF files have been created, the HIPS and SIPS New Project Wizard can be used to specify a Project name, associated vessels, and days for which data was acquired. The "day" name is formatted as YYYY-DOY (year + day of year). Day of year (DOY) refers to a sequential number starting with 001 on January 1 of each year and ending with 365, or 366 in leap years, on December 31 of that year.

Note: DOY is not synonymous with Julian Day Number and should not be referred to as such. The Julian Day numbering system refers to the number of days since noon on January 1, 4713 BC, a system widely used by astronomers.

4.1.1 Creating HIPS Vessel Files (HVFs)

A new HVF is created using the HIPS and SIPS Vessel Wizard, part of the Vessel Editor tool. As the user works through the Vessel Wizard, HVF options must be chosen based on survey systems and configuration. Once the initial HVF is created, additional parameters such as offsets and error corrections must be entered for each individual sensor.

4.1.1.1 HIPS and SIPS Vessel Wizard

The Vessel Wizard will first prompt the user to enter a name for a new HVF file. HVF naming conventions have been standardized throughout the NOAA hydrographic fleet. The following naming convention shall be used for NOAA hydrographic vessel HVF files:

<ship/field unit abbreviation>_<vessel hull number>_<data type + category>.hvf

Table 4.1 contains a list of common data types acquired during OCS hydrographic surveys and example HVF names for each. Note that the field season year is not included in the name; rather, timestamp entries within the HVF are used to track application dates. Only a reference to the principal echosounder or side scan sonar type should be included in the last portion of the HVF name. More detailed equipment specifications and information are recorded within the HVF. For HVFs associated with MBES and SSS data, include the sensor model; for vertical beam echosounder data, use the suffix "VB."

Once an HVF name is entered, the user will be asked to enter specifications for the applicable sonar system, such as sonar type, number of transducers, number of beams, etc. The information requested is typically either based on the physical system configuration or can be located in the sonar user's manual.

Note: HVFs to be used for Elac 1050D and 1180 data should specify 2 swath sensor sections, each having 63 beams to facilitate the "Pad Transducer 1 with NULL beams" option during data conversion, see 4.2.3.1.1.

Data Type	HVF Name Examples
Multibeam Echosounder - Main-scheme Survey Lines or Investigation Lines	"RA_S221_Elac1050D" - NOAA Ship RAINIER, Elac 1050D multibeam "FA_1010_Reson8101" - NOAA Ship FAIRWEATHER launch 1010, Reson 8101 multibeam "BH_S5501_Reson8125" - BAY HYDROGRAPHER, Reson 8125 multibeam
Vertical Beam Echosounder - Main-scheme Survey Lines or Investigation Lines	"RA_S221_VB" - NOAA Ship RAINIER, vertical beam "NRT2_1210_VB" - Navigational Response Team 2, boat 1210 vertical beam
Towed Side Scan Sonar - 100% and 200% Coverage - Other Coverage (e.g., additional investigations, buffer lines)	"TJ_S222_Klein5000" - NOAA Ship THOMAS JEFFERSON, Klein 5000 100-percent side scan sonar "NRT2_1210_Klein3000HF" - Navigation Response Team 2, boat 1210, Klein 3000 high frequency 100-percent side scan sonar
Hull-mounted Side Scan Sonar - 100% and 200% Coverage - Other Coverage	"TJ_1014_Klein5000Hull" - NOAA Ship THOMAS JEFFERSON, launch 1014, hull-mounted Klein 5000, non-100/200 coverage
Echosounder Point Observations - Depth "Detached Positions" (DPs)	"NRT2_1210_EchosounderDP" - Navigation Response Team 2, boat 1210, echosounder DPs "RA_1103_EchosounderDP" - NOAA Ship RAINIER, launch 1103, echosounder DPs
Non-Echosounder Point Observations - Diver Least Depth DPs - Shoreline DPs	"RA_1103_ShorelineDP" - NOAA Ship RAINIER, launch 1103, Shoreline DPs "TJ_1014_DiverDP" - NOAA Ship THOMAS JEFFERSON, launch 1014, Diver DPs

Table 4.1: Example HVF naming conventions for NOAA hydrographic vessels.

4.1.1.1.1 Motion Sensor Options HIPS and SIPS Vessel Wizard will prompt the user to enter what vessel motion data (i.e., attitude data) will be recorded and whether these data should be applied during post-processing. The meaning of "apply in post-processing" for heave is straightforward. If survey data were not logged with heave corrections applied during data acquisition, and heave data (either real-time values or true heave, as discussed in 3.4.1.2) were recorded separately, then apply this correction in post-processing. The standard practice for OCS hydrography is to not correct survey data for heave during data acquisition; hence, "apply in post-processing" is usually enabled for this sensor in the HVF.

The application of roll and pitch is a bit more complicated than applying heave. The user must keep in mind that options to apply roll and pitch will affect any remote heave calculations. (Remote heave is defined as changes in vertical position of the transducer due to roll and pitch acting over a non-zero moment arm between the heave sensor and the transducer). If remote heave compensation is to be performed in HIPS, the vessel coordinate system reference point (RP) entered in the HVF will be treated as the center of rotation and, therefore, should be established as close to the vessel's center of motion as possible.

Many MBES sensors can be configured to acquire bathymetry using roll or pitch beam steering. In these cases, the HVF apply roll & pitch options should be set according to the data acquisition configuration. If roll steering was enabled during acquisition, do not apply roll in post-processing. If roll steering was not enabled, the HVF option to apply roll in post-processing should be checked. Likewise, if pitch steering was enabled during acquisition, do not apply pitch in post-processing. If pitch steering was not used, the HVF option to apply pitch in post-processing should be checked.

Note for Elac MBES system users: For Elac MBES data, the requirement for applying roll in post-processing is directly connected to whether the flat-face refraction (FFR) portion of sound speed correction is to be performed during HIPS SV Correct. (Refer to section 4.2.3.4 for important details regarding Elac FFR in HIPS SV Correct.) OCS recommends that FFR correction be performed during data acquisition, rather than in HIPS, for all flat-face MBES systems. This necessitates use of a sound speed probe at the transducer, see section 3.2.4.

If FFR correction is not performed during post-processing in HIPS (the preferred operating procedure), the option to apply roll in post-processing will have no affect on the data and any angles present in the SVP1 and SVP2 “roll” fields are ignored. For this paradigm (SV Correct without FFR), OCS recommends that the apply roll option be unchecked and the SVP1 and SVP2 “roll” values in the HVF be set to 0.0. Non-zero SVP1 and SVP2 “roll” values may generate SV Corrected swath profiles that resemble a “V” or an upside-down “V”, due to a bug in some older versions of HIPS.

If data quality dictates that Elac data be corrected for FFR in HIPS, the apply roll option must always be checked and the athwartships transducer face mounting angle must be entered into the SVP1 and SVP2 “roll” fields in the HVF. Applying roll in post-processing for Elac data requires that dynamic roll be used in determining the aspect of each transducer face with respect to a horizontally-stratified water column, as part of the FFR calculation in HIPS SV Correct.

4.1.1.1.2 Configuration Options The Vessel Wizard configuration options enable the user to enter offset parameters for “sound velocity” corrections (more appropriately, sound speed corrections as explained in 4.2.3.4), a dynamic draft table, and “waterline” value for the vessel.

Typically, bathymetry data will require sound speed (i.e., refraction) correction during post-processing and the option to “define parameters for sound velocity corrections” should be checked. If this option is checked, the hydrographer will also be prompted to enter any mounting offsets for the sonar transducer. Only large mounting offsets should be entered here. Small offsets will be accounted for during the patch test. However, some MBES systems correct for refraction during data acquisition. If refraction correction has been performed in real-time during data acquisition, sound speed correction during post-processing is generally unnecessary and is not performed. Typically imagery data will not require sound speed correction either, and “defining parameters for sound velocity corrections” is unnecessary for HVFs used only to process data that will not be sound speed corrected during post-processing.

Dynamic draft refers to changes in draft induced by the flow effects of a vessel moving through the water. Corrections for this effect can be applied during post-processing via either a Dynamic Draft table of speed-versus-draft values entered in the HVF or from a “delta draft” time series that is loaded during post-processing. The OCS standard practice is to enter a speed-versus-draft table that is applied in post-processing. Thus, in most cases the option to “create a Dynamic Draft table or speed vs. draft values” should be checked and values manually entered into this table by the hydrographer.

The term “waterline height”, as defined by CARIS, refers to the measured vertical difference between the vessel waterline and the established origin of the local vessel reference frame (RP). This value will be positive if the vessel waterline is below the RP, and negative if the vessel waterline is above the RP. Variations in static draft of the transducer should be accounted for by adjusting the waterline height in the HVF, thus the HVF option to “define vessel waterline height variations” should be checked and the waterline value applied in post-processing.

Note: Some sonar systems must be configured such that depths are reported relative to the waterline, rather than the transducer. In such cases, the value entered for waterline may not be as defined above, and the hydrographer should verify that the combination of values entered in the HVF for transducer vertical offset and waterline do not cause an erroneous vertical correction.

4.1.1.2 HIPS and SIPS Vessel Editor

Once a new HVF has been created with the Vessel Wizard, sensor offsets and additional sensors, such as CARIS "TPE values," (see section 4.2.3.6) can be activated using the CARIS HIPS and SIPS Vessel Editor. It should be noted that HVFs use a left-handed coordinate system, as summarized in Table 4.2. (Be aware that despite the fact that the +Z axis is down, when recording vessel motion positive heave action is up.) The user should verify that offset values determined during the vessel survey adhere to the same coordinate system as the HVF. If this is not the case, surveyed offset values will need to be converted so that the vessel configuration is accurately represented in the HVF.

Coordinate System Component	Direction
+X axis	Starboard
+Y axis	Forward (toward bow)
+Z axis	Down (into the water)
+Pitch	Bow down
+Roll	Starboard up
+Heave	Up (out of the water)

Table 4.2: CARIS HVF coordinate system (a left-hand coordinate system).

Note: Coordinate systems vary among NOAA survey systems and software. This information should be verified in the appropriate user's manual prior to entering offsets into any software or equipment configuration. Coordinate systems for common OCS survey systems are described in Appendix 1, Coordinate_Systems.pdf.

The hydrographer may find it useful to create a three-dimensional Vessel Shape when entering sensor offsets. This image, created using Vessel Editor's Edit > Vessel Shape menu, shows the relative location of sensors as entered in the HVF and can provide the hydrographer with a quick verification that offsets have been entered correctly.

4.1.2 Creating CARIS Projects

To simplify data management, OCS recommends that a separate CARIS Project be used for each type of data acquired for an OCS survey. Project names should include the survey registry number (e.g., H12345 or FOO123), rather than a survey letter designation, and an indicator of the data type. For example, the first 100% of side scan data acquired for survey H12345 might be contained in a CARIS Project named H12345_100SSS. New Projects are created, and any existing Project filing structure can be modified, using the CARIS New Project Wizard. When adding a new Project, the Wizard will request the following data:

- Description – Provide a brief summary of the purpose of the Project and any significant survey-specific information. The bulk of the description can be extracted from the Introduction, Location, and Priority sections of the Project Instructions. Note: Entering a description is important because this is one of the few places in HIPS and SIPS where external metadata can be attached to digital data.

- Owner – List the assigned ship or field party, as well as the Lead Hydrographer (Commanding Officer or Chief-of-Party) and Survey Manager.
- Map Projection – Map Projection establishes the coordinate system to be used for the Project view in HIPS/SIPS. If AUTO_UTM is specified, the coordinate system of the Project view will be based on the ellipsoid manually entered in the HVF. The AUTO_UTM option can be used, provided a Universal Transverse Mercator (UTM) projection on the North American Datum of 1983 (NAD83) has been entered for all HVF files associated with the survey.
- Project Extent – Enter the basic boundaries of the survey area. Project Extent is expressed as a regular (i.e., non-rotated) rectangle. Project Extent should completely cover the assigned survey limits. Note that data brought into a CARIS Project are not automatically clipped to this area; the clipping function is optional and requires user activation. If activated, the default clipping boundary will be the Project Extent, but this may be modified by the user. Refer to the CARIS HIPS and SIPS User's Manual for additional information on clipping data.

4.2 Bathymetry Processing

NOAA hydrographic field units typically acquire bathymetric data using VBES, MBES, or a combination of both. VBES depths are processed using the CARIS HIPS Single Beam Editor tool to review and edit data anomalies. MBES data may be edited in two different ways: using CARIS HIPS Swath Editor tool to edit data in a time-series mode, or using the CARIS HIPS Subset Editor tool to edit data in a spatial mode. In both instances, Bathymetry Associated with Statistical Error (BASE) methods are used to generate, using one or more different algorithms, a digital seafloor model that contains depth and uncertainty information at each model node. In addition to the basic bathymetric layer, auxiliary information layers such as standard deviation of soundings, sounding density, shoal depth, source identification, hypothesis count, and hypothesis strength will be generated depending upon the algorithm used to construct the BASE surface. These BASE surface layers are used to guide the hydrographer to areas that require further examination and/or editing. This concept is explained in greater detail in section 4.2.1.

Unlike VBES and MBES data, depth measurements acquired by leadline, sounding pole and/or diver least depth gauge are positioned using a type of target file referred to as a detached position (DP) and depth data is entered manually in Pydro. Since target files are more frequently used to locate point features such as shoreline items and bottom samples than these types of depth measurements, processing details have been included in 4.4.1.2 .

4.2.1 The BASE Surface Concept

A BASE surface represents bathymetry as a dense grid of statistically derived depth estimates. Various products can be derived from BASE surfaces, including a shoal-biased set of depth estimates for safe vessel navigation. The BASE surface paradigm discussed herein is specifically designed for MBES data, which typically has a high sounding density. Nevertheless, VBES data can also be assimilated into the BASE surface model. The Survey Manager should consult, through his/her chain-of-command, OCS's Hydrographic Surveys Division for the most current guidance on incorporating VBES data into BASE surface data.

4.2.1.1 Base Surface Methods

There are two different algorithms used by NOAA hydrographic field units for creating BASE surfaces: uncertainty weighted grids and the combined uncertainty and bathymetric estimator (CUBE) method. Each of these methodologies is described below.

4.2.1.1.1 Combined Uncertainty and Bathymetric Estimator (CUBE) CUBE is a gridding algorithm developed at the University of New Hampshire (UNH)/NOAA Center for Coastal and Ocean Mapping Joint Hydrographic Center by Dr. Brian Calder. Its primary advantage over uncertainty weighted grids is that it is less susceptible to noise. CUBE works in two stages:

1. Integration of Soundings into Hypotheses - During the first stage, all soundings in the area are grouped into internally consistent depth hypotheses, using the uncertainty of the soundings as a threshold.
2. Disambiguation - After all soundings are integrated, a second stage determines which hypothesis at each node is the most likely to be the seafloor. There are three disambiguation methods in the CARIS HIPS 6.1 version of CUBE. The simplest is by density, where the hypothesis with the most soundings supporting it is chosen. The second is by locale, where the hypothesis most consistent with its neighbors is chosen. The third method, density and locale, combines these two methods. First, the density method is used. Then, for any nodes where this method was ambiguous (thresholded by the ratio of the highest density hypothesis to the next highest density hypothesis), the locale method is used. The density and locale method seems to yield the best results in most circumstances and should be the method chosen by default.

The CARIS HIPS integration is well documented in the CARIS HIPS and SIPS User's Manual. This manual should be referenced for details on the workings of the algorithm and explanations of the user interface.

When editing a CUBE surface, the user may opt to edit soundings or to edit hypotheses. For NOAA hydrographic survey data, it is critical that only sounding edits be used to correct gridding problems. This is primarily because hypothesis edits exist only in the context of a single grid, and will be lost if that grid is recomputed.

4.2.1.1.1.1 CUBE Parameters There is a small parameter file called "CUBE_Params.xml" in the HIPS system directory that is referenced in the HIPS environment. The values in this file control the behavior of the CUBE gridding and disambiguation processes. The meaning and effect of each parameter is described below:

Estimate Offset Value (EOV)

- The threshold used to determine whether to spawn another hypothesis.
- Default is 4.0 times the TPE (see section 4.2.3.6).
- A reasonable value is 2.0.
- If TPE is overestimated, a smaller value (1.0) should be used.
- Used to separate noise from seafloor.
- Too large a value will lead to lots of noise integrated into a single hypothesis.
- Too small a value will lead to "daisy cutting" where small features are removed.

Horizontal Scale Value (HSV)

- Controls the shape of the weighting curve near a node.
- Default is 2.95.
- A reasonable value is 0.5.
- Appropriate value depends on TPE estimates. Overestimation of horizontal error or high HSV leads to small features being smeared and detail lost.

Capture Distance Scale

- One of the limits on propagation distance.
- Default is the greater of 0.5m or 5% depth.
- “Complete” standard is the greater of 2m or 20% depth.
- “Object Detection” standard is the greater of 0.4m or 4% depth.
- The smaller the value, the more null nodes and noise, but better honoring of small features.

Null Hypothesis

- A Null Hypothesis occurs when all hypotheses are rejected as unlikely.
- For the null hypothesis test to reject a hypothesis, a single sounding, single hypothesis node must have “Null Hypothesis Min Neighbors” qualified neighbors with a hypothesis strength below “Null Hypothesis Strength Max”, the ratio of the standard deviation of the sounding and its neighbors to the standard deviation of the neighbors must be greater than threshold “Null Hypothesis Ratio”, and “Enable Null Hypothesis” must be set to true.

Locale Disambiguation

- In “density and locale” disambiguation, a locale test is performed when the hypothesis strength exceeds the “Density Strength Cutoff Value”.
- In the locale test, a set of hypotheses is compared to the mean of neighbors with hypothesis strength less than “Locale Strength Max Value” within “Locale Radius Value” of the subject node.

OCS recommends that all field units use the parameter set that is required for their survey. If a “Complete” survey is required, use the “Deep” parameter file. If an “Object detection” survey is required, use “Shallow” parameter file. Both of these parameter files will be available through the HIPS distribution.

4.2.1.1.2 Uncertainty Weighted Grids In order to generate uncertainty-weighted BASE surfaces, TPE (see section 4.2.3.6) must be calculated for each sounding. TPE accounts for the a priori horizontal and vertical components of uncertainty associated with each sounding measurement. TPE is formulated from the summation of the modeled uncertainties for all subsystems included in the overall hydrographic survey system (e.g., water levels, tide zoning, attitude sensor error, navigation sensor horizontal position error, sound velocity profile error, sonar bottom detection method, etc.). The sources of uncertainty values include (or may be combination of) manufacturer specifications, theoretical values, and empirical observations from the field. These values are entered into the HVF.

OCS-recommended uncertainty values are contained in the CARIS HVF Uncertainty Values.pdf in Appendix 4. The uncertainty values described in the appendix are provided as guidance for use in standard NOAA hydrographic surveys. These values do not cover the breadth of operations encountered by all field parties, nor do they cover the range of equipment configurations possible for any particular vessel. As such, these values should serve a starting point in developing a vessel's error model. Any deviation from the attached values should be completely described in the applicable Descriptive Reports and DAPR.

In general, soundings (observation points) do not coincide with grid nodes (BASE surface estimation points). To account for this, the vertical component of a sounding's TPE is propagated to a grid node according to a power law that models the increase in uncertainty as a function of three variables: distance between sounding and node, the sounding's horizontal component of TPE, and grid node resolution. The amount of weight an observation exerts on a given BASE estimation point is inversely proportional to the propagated vertical uncertainty of the observation. See Figure 4.1 .

$$\hat{\sigma}_P = \hat{\sigma}_V \left[1 + \left[\frac{\parallel x_i - n_j \parallel + s_H \hat{\sigma}_H}{min(\Delta x, \Delta y)} \right]^{\alpha} \right]$$

Figure 4.1: Model for propagated uncertainty in depth

Where $\sigma_V$and $\sigma_H$are the vertical and horizontal components of TPE (resp.), S_H is a scale factor representing the worst case error that horizontal TPE can contribute, $x_i$and $n_j$are the location of the sounding and estimation node (resp.), $\Delta x$and $\Delta y$are the two-dimensional spacing of grid nodes, and the exponent is a heuristic to control overall growth of propagated uncertainty, σ_P. The HIPS BASE surface algorithm uses a value of 1.0 (HIPS has already scaled $\sigma_H$by 1.96, for a 95% confidence interval) and an αvalue of 2.0.

Theoretically, every sounding can affect every node in a BASE surface encompassing a survey area. For computational efficiency, HIPS limits a sounding's radius of influence on surrounding nodes through the following “spreading conditions.” (1) At a minimum, each sounding affects all nodes within a radius of 0.707 times the grid resolution of its position; i.e., within half the distance of the diagonal on a regular (square) grid. Hence, a given sounding will affect at least two to four nodes, depending on where it is situated with respect to the nodes. (2) Each sounding will propagate at most a distance determined by a user-specified threshold of propagated vertical uncertainty. The uncertainty threshold is expressed in HIPS according to an IHO sounding error model (see Figure 4.2); that is, an estimate of all constant errors (a) and depth-dependent errors (b times d) are summed in quadrature as shown in Figure 4.3.

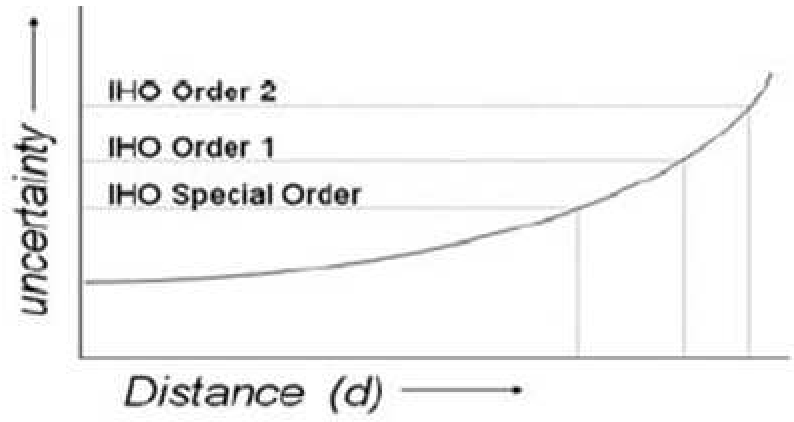

Figure 4.2: Generalized uncertainty growth curve with respect to sounding radius of influence (d).

$$\pm\sqrt{a^2 + (b \cdot d)^2}$$

Figure 4.3: IHO total sounding error budget model, 95% confidence level (a and b are constants, d is depth)

OCS requirements for the accuracy of measured depths, as set forth in the HSSD, are adapted from IHO S-44, Standards for Hydrographic Surveys, 4th Edition, which defines Special Order (a=0.25 meters, b=0.0075), Order 1 (a=0.5 meters, b=0.013 or 1.3% of depth), and Order 2 (a=1.0 meters, b=0.023 or 2.3% of depth) standards. OCS specifies that the total sounding error in a measured depth at the 95 percent confidence level, after systematic and system specific errors have been removed, shall not exceed the IHO Order 1 standard in depths up to 100 meters and shall not exceed the IHO Order 2 standard in deeper waters. If either an IHO Special Order standard or a user-defined accuracy is required for a survey, these requirements will be stated in the project Project Instructions.

4.2.1.1.3 Other BASE Weighting Methods in HIPS CARIS HIPS allows BASE surfaces to be generated using either swath-angle weighting or the uncertainty weighting discussed in the previous section. Swath-angle weighted BASE surface nodes do not incorporate TPE (see section 4.2.3.6) and, hence, node "uncertainty" is not available therein. Unless specifically stated to the contrary, use of the term "BASE surface" in conjunction with OCS hydrographic surveys refers to those surfaces generated using the uncertainty weighting method.

4.2.1.2 BASE Node Attributes

The depth at a given BASE surface grid node, n, is the mean depth (weighted by propagated depth uncertainty) of the set of N soundings whose domain, Di, contains n. Likewise, the uncertainty at a given node is the mean uncertainty (weighted by propagated depth uncertainty) of all the soundings contained in set N. See Figure 4.4. Note that the depth at grid node n is the weighted mean of soundings 1, 2, and 3. Sounding 4 is not included because its radius of influence does not encompass grid node n.

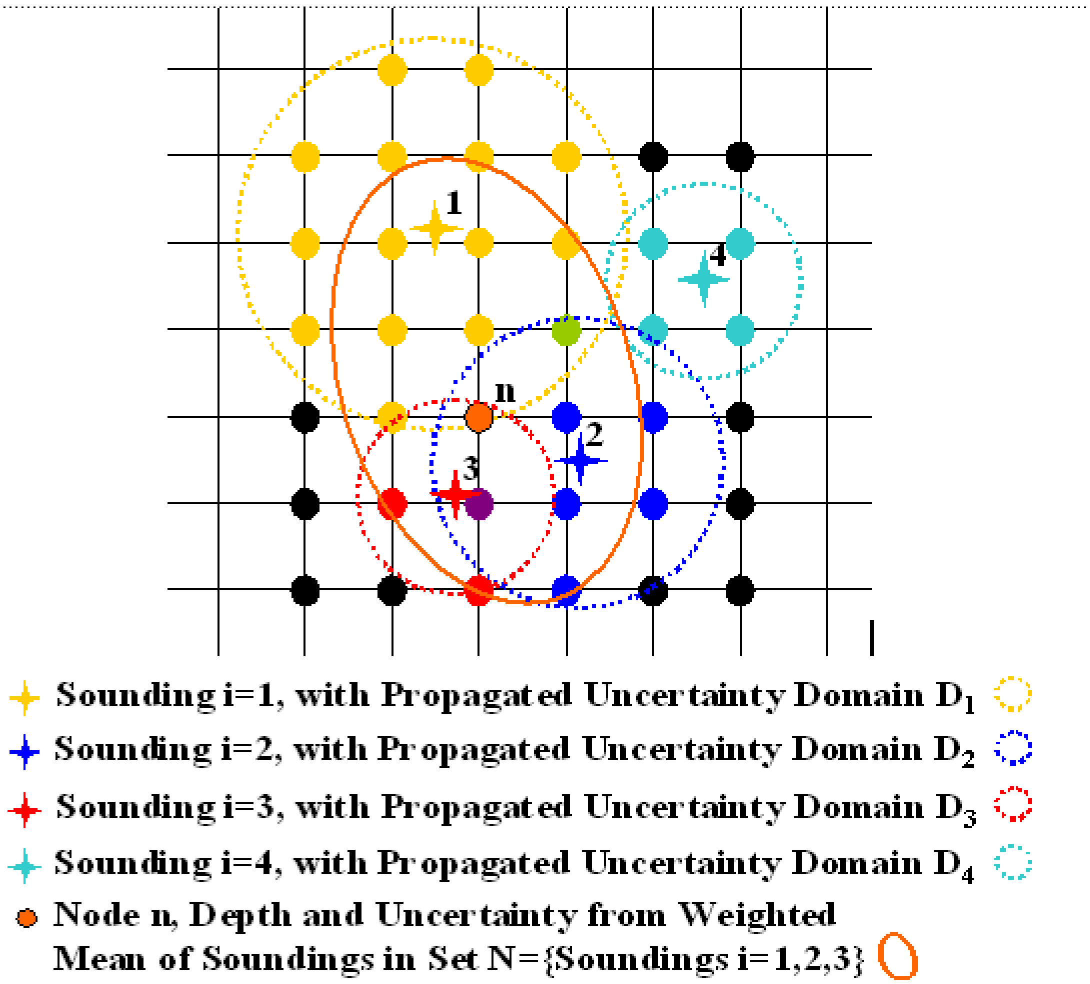

Figure 4.4: Formulation of BASE surface nodes from soundings

In addition to depth and uncertainty, users can include five additional attributes in the BASE surface nodal data. The definitions of the seven nodal attributes are summarized below. Note that all node statistics are computed from the set of surrounding soundings whose propagated vertical uncertainty passes a user-supplied threshold (IHO Order):

- Depth - weighted-mean depth of soundings that contribute to a node; weighting is inversely proportional to the propagated vertical uncertainty of the soundings.
- Uncertainty - weighted-mean vertical component of TPE (see section 4.2.3.6) of soundings that contribute to a node; weighting is inversely proportional to the propagated vertical uncertainty of the soundings.
- Density - number of soundings that contribute to a node.
- Std_Dev - sample standard deviation (not weighted) of soundings that contribute to a node; multiply Std_Dev by 1.96 to obtain the 95% confidence interval.
- Shoal - shoalest sounding from the set of soundings that contribute to a node.
- Mean - sample mean of the set of soundings that contribute to a node.
- Deep - deepest sounding from the set of soundings that contribute to a node.

4.2.2 Bathymetry Processing Flow Diagrams

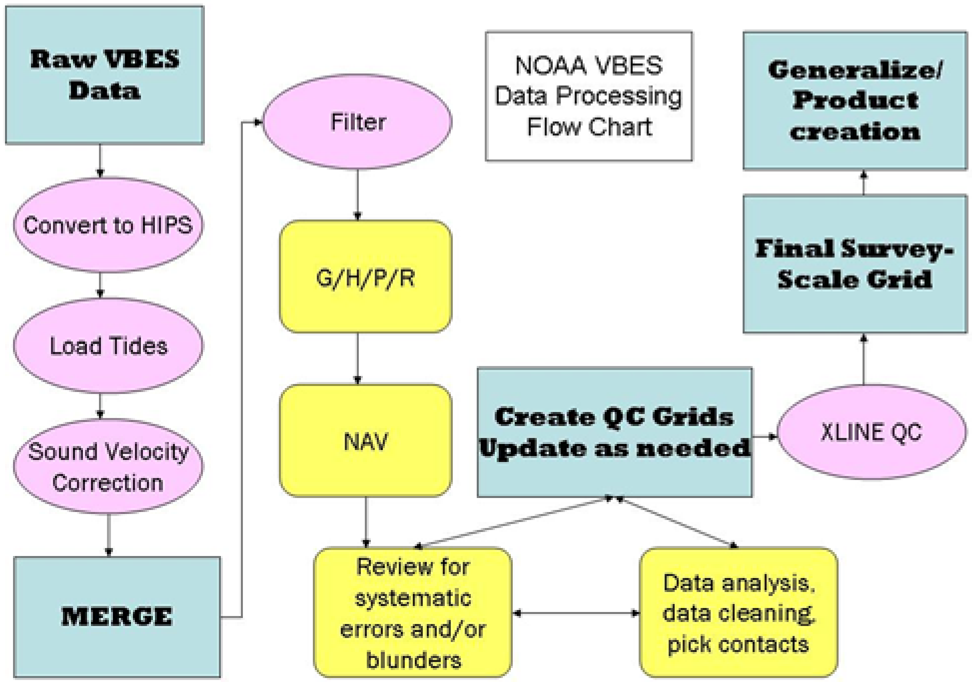

Figure 4.5: Processing flow diagram for VBES data

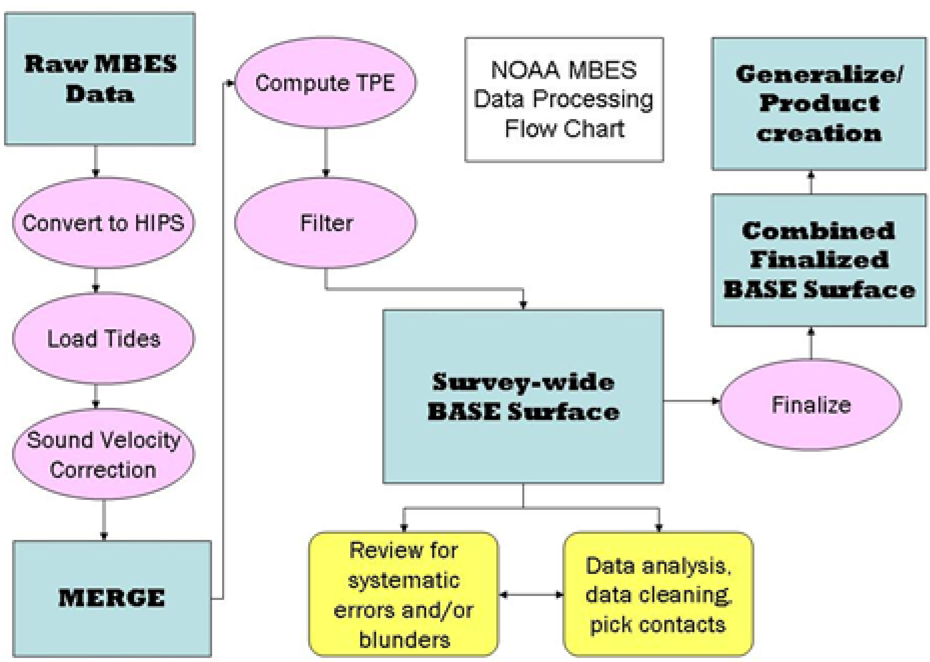

Figure 4.6: Processing flow diagram for MBES data

4.2.3 Daily Batch Processing

A number of processing tasks need to be performed on "raw" bathymetry data (i.e., unaltered data in the format recorded by the acquisition software) before any detailed analysis and evaluation can occur. Some of these daily tasks are interdependent, and the specific sequence is critical. The recommended ordering of daily batch processing tasks is as follows:

1. Conversion 4.2.3.1
2. Load Tides 4.2.3.2
3. Load True Heave, if applicable 4.2.3.3
4. Sound Speed Correction 4.2.3.4
5. Merge 4.2.3.5
6. Compute TPE 4.2.3.6
7. Filter 4.2.3.7
8. Add to Coverage BASE Surface 4.2.3.8

Most of the tasks above can be semi-automated using the HIPS "Batch Processor" tool. Data format dictates how specific batch processing actions should be configured; thus, a separate HIPS Batch Processing File (.hbp) is needed for each raw data format type.

In general, all of the aforementioned tasks should be completed for any type of echosounder data. However, steps 6-8 will not be necessary for VBES data that will not be incorporated into a BASE surface. A basic set of batch processing files can be specified for each data type and reused on the appropriate set of survey lines acquired each day. In some circumstances, either creation of custom batch processing files or manual processing of one or more tasks, line-by-line, in non-batch mode may be necessary. For example, conversion and filtering options may need to be customized to reflect changes in echosounder performance as weather conditions varied throughout a survey day.

4.2.3.1 Conversion

CARIS HIPS supports numerous different data formats that can be used to record bathymetry. During conversion, HIPS uses the raw data to create a single, proprietary data format that will be used in subsequent CARIS processing routines. These files in CARIS HIPS format are referred to as "HIPS files" or "HDCS files".

Depending upon the system type and setup, recorded raw data may have been corrected for factors such as vertical (depth or height) offsets, vessel motion, or acoustic refraction during acquisition. It is critical that HVFs account for any real-time corrections performed, so that "double corrections" do not occur during post-processing.

If an HVF error is discovered subsequent to post-processing, it may be necessary to reapply certain correctors and re-merge. Depending upon the error, a re-conversion may be required; however, most HVF settings do not impact the HIPS data conversion process. (HVF settings that can directly affect the data conversion process include VBES draft and MBES beam numbering.) Data processors should not automatically resort to time-consuming re-conversion and re-processing of a significant amount of data upon discovering an HVF error. If unsure whether data repairs are necessary, the Survey Manager should consult, through his/her chain-of-command, the Hydrographic Systems and Technology Program for assistance.

The following sections contain guidance for converting common raw bathymetry data formats used by OCS into HDCS files. Relevant background information is provided, followed by a table of guidelines for specific HIPS and SIPS Conversion Wizard settings related to each raw bathymetry format.

Note: HIPS uses the same Conversion Wizard as SIPS for a given raw data format. Options related to conversion of sonar imagery stored in raw MBES data are not addressed in this section; see 4.3.3.1 for imagery conversion details.

4.2.3.1.1 Elac (XSE) In HIPS, “Elac” data refers to SEABEAM multibeam system data stored in Data Exchange Format (XSE). SEABEAM 1050D and 1180 multibeam system (hereafter, Elac) data are acquired in XSE format using the Hydrostar ONLINE (Hydrostar) software package. Some detailed knowledge of the Elac MBES system is necessary to understand the data conversion options available in HIPS. SEABEAM manuals have historically contained errors introduced during language translation; thus, the information contained in this manual is fairly extensive and represents the best knowledge of the 1050D/1180 systems as used by NOAA for hydrographic surveying. Most notably, system beam geometry differs quite a bit from the information provided in the SEABEAM manuals. Additional Elac/SEABEAM reference materials are included on the Hydrosoft DVD.

Elac 1050D (50 or 180 kHz) and 1180 (180 kHz) multibeam systems utilize a pair of transducers, and echosounding is achieved using a Rotating Directional Transmission (RDT) method. Sonar transmission occurs across adjacent sectors in a 3-step “subfan” process, as shown in Figure 4.7.

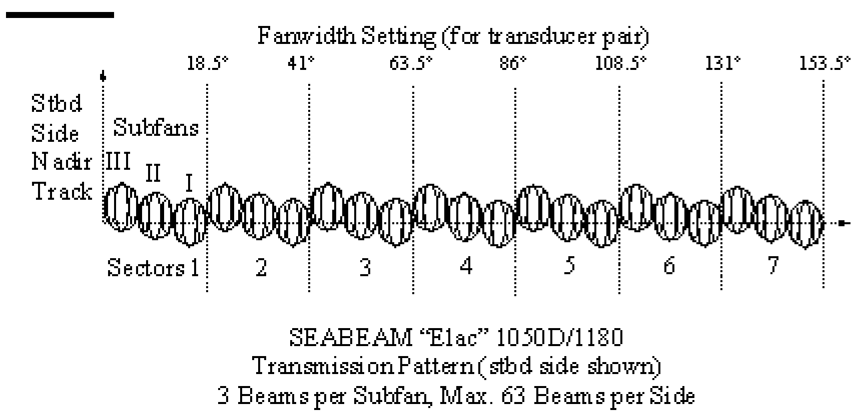

Figure 4.7: Elac RDT method.

For each of the 3 subfans within a sector, the receiving beamformer calculates 3 beams, for a total of 9 beams per sector. There are 7 fanwidth settings possible, the maximum of which (153.5º) utilizes 7 sectors, for a total of 126 beams within a “virtual swath.” The term “virtual swath” is used to emphasize the fact that (1) the transducer arrays transmit quasi-simultaneously so that not all the beams lie in the same plane and (2) the transducer arrays are mounted a finite distance apart in such a manner that a real gap exists between the 2 half-fanwidths. HIPS Swath Editor portrays the 2 half-fanwidths as being adjoined at nadir and all beams as being within a single ping-plane. Both (1) and (2) are clearly visible in HIPS Subset Editor.

Bathymetry datagrams are stored starboard-to-port in the XSE format; however, the HIPS Elac converter gives the options to number beams from starboard-to-port or from port-to-starboard. The OCS standard practice is to number beams from port-to-starboard. Additionally, HIPS defaults to numbering XSE beams from 1 to N, where N depends on the maximum fanwidth setting in Hydrostar. The 1-to-N beam numbering can be overridden via the "Pad Transducer 1 with NULL beams" option. Because the 1050D and 1180 systems compensate for roll during beam forming, OCS recommends padding be used to reference beam numbering to beam angle (from nadir); i.e., given the maximum number of beams possible, 126, the nadir-most pair of beams will always be numbered 63 and 64, see Table 4.3.

Fanwidth (degrees)	Number of Beams, N	Beam #s with padding
153.5	126	1-63, 64-126
131.0	108	10-63, 64-117
108.5	90	19-63, 64-108
86.0	72	28-63, 64-99
63.5	54	37-63, 64-90
41.0	36	46-63, 64-81
18.5	18	55-63, 64-72

Table 4.3: Hydrostar fanwidth settings, resulting number of beams in multibeam swath, and beam numbers assigned to transducer 1 and 2 in HIPS using padding.

An additional complication in Elac data conversion is due to the system's use of flat-faced transducers. The "Surface Sound Speed (manual or interpolate)" conversion option dictates what goes into an "originalSoundVelocity" file, which is used during the flat-face refraction (FFR) calculation if it is performed during HIPS SV Correct. The manual option allows the user to enter originalSoundVelocity data in the dialog; the interpolate option sets the originalSoundVelocity data equal to a linearly-interpolated value of sound speed at the transducer depth based on the first sound speed profile encountered in the XSE file. OCS recommends that FFR be performed during data acquisition (rather than in SV Correct) using sound speed data from a probe mounted at the transducer depth (see 4.2.3.4).

Options	OCS Guidelines
Beam Numbering - starboard-to-port - port-to-starboard	The OCS standard is for MBES beams to be numbered from Port-to-Starboard.
Surface sound speed - Manual - Interpolate	OCS recommends performing FFR during data acquisition. If data quality dictates that FFR be performed during SV Correct, OCS recommends using a value interpolated from the first sound speed profile in the XSE data file.
Pad transducer 1 with NULL beams	OCS recommends padding transducer 1 with NULL beams. Note: For this to work properly, the HVF must be configured with 2 transducers, each specified to have 63 beams (126 beams total).

Table 4.4: OCS guidelines for converting Elac data.

4.2.3.1.2 Generic Sensor Format (GSF) Generic Sensor Format (GSF) may be used to store data from a variety of VBES and MBES system configurations. GSF is particularly well suited for storing data that have been subject to real-time corrections during acquisition. As noted in 4.1, any real-time corrections in the logged data must be accounted for when creating the HVF. Real-time corrections may also affect processing decisions made in HIPS.

As compared to the Daily Batch Processing steps presented in 4.3.3, the state of a given

GSF dataset may range from raw (i.e., no corrections applied) to a condition where steps 2, 3, and 4 have already been completed. The options for converting GSF data into HDCS files are fairly simple because much of the behavior of the converter cannot be manipulated by the user. The GSF format includes a standard ping flag definition to indicate whether data are “on line” (e.g., data from a planned survey line) or “off line” (e.g., data in between lines, during turns, transits, etc.). The only choice a user must make during HIPS conversion of GSF data is how to treat these off-line data.

Options	OCS Guidelines
Off Line Data - reject off line data	Typically, “off line” data should be rejected

Table 4.5: OCS guidelines for converting GSF data.

4.2.3.1.3 HYPACK HYPACK is the standard data format used by NOAA hydrographic field units to log VBES data. HYPACK software may also be used to store data from a variety of MBES systems via an additional software module called HYSWEEP. For OCS hydrographic survey data, HYPACK VBES files should be recorded using a DOY (erroneously termed “Julian Date” in the HYPACK software) file extension. MBES data, recorded using HYSWEEP should be logged as ASCII *.HSX (HYSWEEP Survey Extension) files.

Within the raw HYPACK file, data recorded from each sensor in the acquisition system is assigned a “device number.” This numbering scheme will vary according to the specific hardware configuration used to record the data. During conversion, device numbers can be specified to correlate each sensor’s data string with a specific type of data (e.g., echosounder, heading, navigation, etc.). If no device numbers are specified, the converter will look for sensor data using known NMEA device strings. Specifying device numbers during conversion ensures that HIPS does not incorrectly identify a data string. Device numbers can be verified by reviewing a raw HYPACK line file in a text editor, such as WordPad, in which each device number will be listed adjacent to its respective device name.

4.2.3.1.3.1 VBES Data When logging VBES data, HYPACK records depth values directly from the echosounder, rather than two-way acoustic travel times. For OCS hydrographic survey data, field units must recalculate VBES depths using an actual measured sound speed profile during post-processing. HIPS will assume an estimated sound speed of 1500 m/s was applied to data during acquisition and uses that value to determine a two-way acoustic travel time for each sounding. HIPS can than recalculate VBES depths using a measured sound speed profile.

Note: If using a VBES system in which the speed of sound through water can be manually entered, the hydrographer must enter 1500 m/s to facilitate the above HIPS process, as noted in section 3.2.3.

If dual-frequency VBES data are being converted, high- and low-frequency soundings are stored side-by-side in the HYPACK raw data record. During conversion, each sounding will be flagged as either “Primary” or “Secondary” in the order in which it appears in the datagram. For example, if the high frequency depth is listed first in the record and the user chooses “Primary, Secondary” for conversion, the high frequency depth will be flagged Primary and the low frequency depth will be flagged Secondary. Primary soundings are also flagged “Selected” by default in HIPS, and only Selected depths will be carried through to final processing. Users may override the Primary/Secondary flagging assigned during conversion to force a depth into, or remove one from, the set of Selected depths.

Note: In dual frequency systems, the low frequency beam width will be wider than the high frequency beam width. If the low frequency return shows a shoaler depth than the high frequency, it often indicates a feature offset from the vessel trackline. The least depth of such a feature may not have been captured by the low frequency signal; thus, the hydrographer should note the feature's position and perform a development (see 4.4.8).

4.2.3.1.3.2 MBES Data Converting HYSWEEP MBES data is nearly identical to converting HYPACK VBES data. The primary differences are that the user must select raw *.HSX files for conversion and choose the "Multibeam" option for soundings, rather than Single Frequency or Dual Frequency as would be required for converting VBES data. Device numbers should still be specified as described in the beginning of this section.

Options	OCS Guidelines
Single Frequency	If Single Frequency VBES data is being converted, it will automatically be classified as "Primary".
Dual Frequency	The OCS standard is to read in high frequency as "Primary and low frequency as "Secondary".
Multibeam	For HYSWEEP MBES data, simply choose the multibeam option.
Static Draft - apply during conversion	Typically, static draft should not be applied during conversion. The OCS standard is for sensors to be referenced to a vessel RP and static draft to be accounted for via a "waterline" correction entered in the HVF. Refer to section 4.1.1.1.2.
Device Numbers	If the hardware setup in HYPACK is unambiguous, then blank device numbers may work fine; OCS recommends explicitly stating the device numbers during conversion.
Sound Velocity	Data acquired for OCS hydrographic surveys shall be corrected for sound speed using actual measured sound speed profiles. For HYPACK data, this process is performed in HIPS.

Table 4.6: OCS guidelines for converting HYPACK data.

4.2.3.1.4 Simrad The Simrad data converter is designed for use with data from Kongsberg Simrad multibeam systems, such as the EM1002 or EM3000. Two notable options are available when converting Simrad data, shortening line names and decimating attitude data.

Simrad generated survey line names can be quite long. During conversion, the user can opt to modify raw line file names into 12-character HIPS line names using the format YY-DDD_HHMMSS (2-digit year + DOY + integer hour, minute, second, based on the starting date and time of the line data).

To reduce file size, attitude data can be decimated during conversion. Often, the output rate of attitude sensors used during multibeam data acquisition can be unnecessarily large (e.g., higher than 25 Hz), creating very large attitude data files in HIPS. The attitude data decimation factor determines the ratio of attitude data that is converted. For example, using a factor of 1 converts all data; a value of 10 converts every tenth attitude record.

Options	OCS Guidelines
Shorten Line Names	OCS recommends shortening line names.
Attitude Data Decimation Factor	A minimum attitude sample rate of 25 Hz is recommended by OCS. Do not decimate attitude data beyond this value, e.g., if attitude sample rate is 100 Hz, do not decimate attitude data by a factor greater than 4.

Table 4.7: OCS guidelines for converting Simrad data.

4.2.3.1.5 Extended Triton Format (XTF) The eXtended Triton Format (XTF), created by Triton Imaging, may be used to store data from a variety of MBES systems. (Imagery data can also be acquired in the XTF format, as discussed in 4.3.3.1.4.) XTF datagrams are comprised of a Triton-defined "header" attached to an optional manufacturer-specific sensor data packet. XTF is a common data format within OCS, primarily due to the widespread use of Triton Imaging's IsisSonar data acquisition software.

Three datagram types must be considered when making choices for multibeam XTF conversion in HIPS: "bathy," "raw navigation," and "attitude." All three of these datagrams may be present in a raw XTF file. Critical sensor data can be logged in multiple datagrams, and may also be recorded in multiple locations within the bathy datagram, as described below. Navigation sensor data can be stored in both the bathy and the raw navigation datagrams. Heave, pitch, roll, and "gyro" (i.e., heading) data can be stored in both the raw navigation datagram and the attitude datagram. Gyro data can also be stored in the bathy datagram. While this sensor data may appear redundant, data quality can vary. The hydrographer will want to apply the most accurate sensor data available, and should consider factors such as data source, time latencies, and update rates when determining which data to associate with sounding data. Which particular sensor fields are meaningful to the bathymetry is entirely dependent on how the acquisition software is configured to log XTF data.

Raw navigation datagrams are typically present in XTF data only when Precise Timing is employed (see 3.2.4.1.2). Since Precise Timing corrects for latencies in data transmission, OCS recommends using the raw navigation datagram for all sensor data if available. If the sonar system has not been configured for Precise Timing, navigation data can also be stored in two fields, "ship" and "sensor," within the XTF bathy datagram. The primary difference between the "ship" and "sensor" fields is how the data is time stamped. "Ship" navigation is associated with the time logged in the XTF header, while each "sensor" navigation string is individually time stamped. Options for obtaining attitude and gyro data will vary depending on the choice made for navigation data.

When converting bathymetry data, the user may choose to automatically flag-reject soundings according to their quality value. The encoding of sounding quality flags is entirely a function of the specific echosounder system being used and how the HIPS converter maps those flags to four discrete levels: 0, 1, 2, and 3. Refer to the CARIS HIPS and SIPS User's Manual for additional information on sounding quality flags.

4.2.3.2 Load Tides

For NOAA charting purposes, hydrographic sounding data must be merged with water level observations relative to the local "chart datum," typically mean lower-low water (MLLW). The HIPS Load Tide tool creates a water level height time series in each survey line directory that is appropriate for the position and time of each line.

If tidal effects throughout a survey area are complex or if multiple water level stations are located nearby, an optional zone definition file (.zdf) can be used to express how the amplitude and phase of the tide within a given area is related to available water level station data. For each zone, a reference water level station, time corrector, and range corrector will be provided. This technique called discrete tidal zoning does not account for the effects of spatially varying harmonic and non-harmonic effects on the water levels. The accuracies achieved by this method may be inconsistent from one survey area and/or time periods to others, and the resulting uncertainties may be difficult to quantify.

A tide or water level file must be loaded prior to merging data in HIPS, but actual water level data may not yet be available. Thus for daily data processing, a zero or predicted tide file will often be used. If survey data were compensated for water level variances during acquisition or if water level measurements are not necessary for the survey area (e.g., some non-tidal rivers or lakes), a “zero tide” file must still be loaded to enable the HIPS merge process.

Note: Non-tidal areas are still subject to water level variances due to factors such as wind, rain, barometric pressure changes, and freshwater runoff.

If preliminary or verified water levels are available, the most accurate of these data should be applied (see 4.2.5.1).

Note: HIPS currently supports a “weighted averaging” option for zoned tides. This option applies data from multiple water level stations by weighting observed water level measurements based on the inverse of the station-to-vessel distance. OCS does not recommend using HIPS “weighed averaging,” because the two-dimensional character of the survey area is not taken into account (i.e., the station-to-vessel distance vector may cut through land).

4.2.3.2.1 Tidal Constituent and Residual Interpolation (TCARI) Tidal Constituent and Residual Interpolation (TCARI) was designed for total water levels relative to Mean Lower Low Water (MLLW)at selected hydrographic survey areas along the coast by the spatial interpolation of tidal data. The model spatially interpolates the harmonic constants (used to predict the astronomic tide), tidal datums, and residual water levels (i.e., the non-tidal component or the difference between the astronomically predicted tide and the observed water level) using the values at a combination of operational and historical stations. The method works best in regions where there is an abundance of high quality tidal data surrounding the survey area. TCARI methodology has the potential to yield water level correctors with increased accuracy and reduced uncertainty.

For several years NOAA has been investigating more sophisticated water level interpolation schemes as part of the TCARI program. The objective has been to eliminate or reduce some of the drawbacks and uncertainties in using discrete tidal zoning, including the vertical "stepping" effects typically produced across hydrographic survey project areas, the use of an averaged time difference correction for both high and low waters, and the limitations of tidal zoning corrections in areas of large range and time differences and changes in tide type (i.e changes in the shape of the tide curve).

The use of TCARI, just as in discrete tidal zoning, requires the oceanographer to evaluate and understand the tidal characteristics of the survey areas. Success in either method requires information from historical tide stations and other sources. Gaps in information limit both methodologies. And both methodologies require tide stations to be in operation during survey operations. TCARI first requires the development of a model grid to cover the survey areas and then requires a spatial field of harmonic constants from historical stations for the interpolation instead of just the average time and range of tide required by tidal zoning. Finally, TCARI planning requires an analysis of the non-tidal residual across the survey area to determine the location and number of stations to be in operation during the survey. TCARI grid files, interpolation weighting functions, and harmonic constant files are created during planning and sent to the survey platform. Survey vessels must obtain the observed data from the specified tide stations during the survey so that TCARI can apply the interpolated water level residuals in the process.

NOAA intends to fully implement TCARI for NOAA internal platforms this 2008 field season however it should be noted that TCARI may not be used or suitable for all survey areas. In the near term, it is expected that both TCARI and traditional tidal zoning will be used and the applicable tool will be determined by CO-OPS in the planning stage on a survey by survey basis. CO-OPS will either send TCARI program files or discrete zoning to the field but not both. Field units receiving a TCARI grid from CO-OPS can load it into Pydro with water level data to create tidal reducers for the survey's bathymetry. Once TCARI has create the tide files, the data can be merged in CARIS (loading tides option is not necessary, you will not need a .zdf file).

For final tide correctors, the survey vessel should generate and submit a "Request for[Smooth] Tides", stating on the request that TCARI was used for that particular survey.

CO-OPS will review and quality control the TCARI grid sent to the survey vessel and if no discrepancies or problems are found, will send the vessel a note stating that the preliminary grid can be used for final tidal correctors. If CO-OPS finds discrepancies or problems, then CO-OPS will re-evaluate and determine the best solution.

Refer to the TCARI field SOP in the Chapter 4 Appendix for more information.

4.2.3.2.2 Compute GPS Tide The HIPS Compute GPS Tide function theoretically reduces soundings to chart datum based on a post-processed kinematic (PPK) GPS ellipsoid height. The user must also know the ellipsoid height-to-MLLW-datum separation to use this function. Since OCS has not operationally implemented PPK, Compute GPS Tide shall not be used for processing hydrographic survey data for submission.

4.2.3.3 Load True Heave

If POS/MV TrueHeave was logged during data acquisition, these files should be loaded using the HIPS Load True Heave tool. Loading true heave files will not overwrite real-time heave values that are automatically recorded in a raw *.xtf file. However, once true heave files have been loaded, CARIS will automatically apply true heave unless the user manually deletes the true heave files from the PVDL directory. The hydrographer can review/edit the true heave time series data using HIPS Attitude Editor. TrueHeave data will be applied to survey soundings during either HIPS SV Correct (if performed) or Merge, provided the "apply in post-processing" option for heave has been checked in the HVF.

Notes: 1) Simrad data is typically compensated for real-time heave during acquisition. To avoid a double-correction, the Simrad-based TrueHeave algorithm in HIPS applies a vertical adjustment equal to the difference between TrueHeave and real-time heave. 2) There is a 14 second timing offset between data acquired using Elac sonar systems and TrueHeave data which introduces a significant heave artifact into Elac data when TrueHeave is applied. For this reason TrueHeave should not be applied to Elac data.

4.2.3.4 SV Correct

Correcting sonar data for the speed of sound (through water) actually refers to performing a refraction correction based on a sound speed profile of the water column. Variations in the speed of sound (primarily due to water temperature variations, or thermocline) result in refraction (bending) of sonar beams. The speed of sound through water will decrease as water temperature lowers, causing a sonar beam to bend downward and creating depth and position errors in any measurement calculated based on travel time and an assumed linear travel path of the sonar beam. Figure 4.8 illustrates the effect of refraction. The sound wave striking the thermocline at point B slows down, while point A on the same sound wave continues at the original speed until it strikes the thermocline at C. As a result, the sonar beam bends downward.

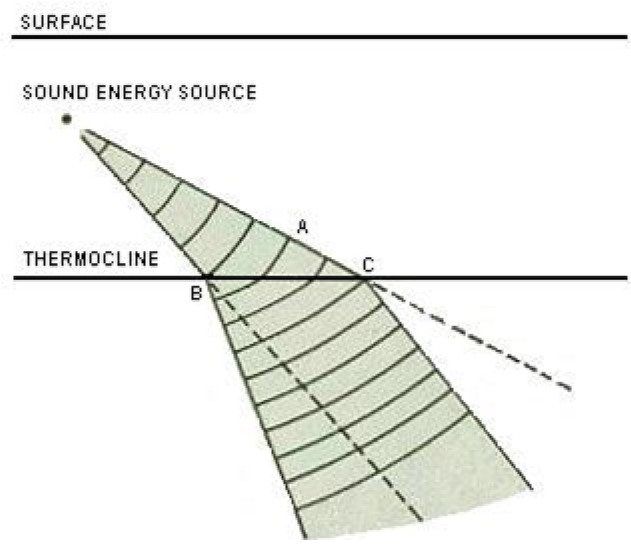

Figure 4.8: Sonar refraction due to thermocline.

Note: Although often referred to as sound velocity correction, bathymetry data are actually corrected for sound speed, as only the scalar magnitude of velocity (i.e., speed) is used by HIPS. However, when referring to a specific manufacturer's process, the manufacturer's terminology will be used in this manual, e.g., CARIS' terminology (sound velocity or SV) will be used when referring the CARIS procedure "SV Correct".

If sound speed corrections have not been applied in real-time during data acquisition, a HIPS Sound Velocity Correction must be performed using the SV Correct tool. Two stages of sound speed processing are possible in HIPS: (1) Adjustment of sonar beam (reported) launch angle through flat face refraction (FFR), which is not applicable for all MBES systems, and (2) adjustment of sounding horizontal position and depth through geometric beam ray-tracing. During HIPS SV Correct, survey line "ObservedDepths" data (alongtrack/acrosstrack position and depth with respect to the vessel RP) are recalculated from "SLRange" data (beam launch angle, one-way travel time) and corrected for acoustic refraction as well as (if indicated in the HVF) waterline, dynamic draft, heave, roll, and pitch.

Note: the "Apply" box in the HVF must be checked for waterline, dynamic draft, and each attitude sensor for these data to be applied.

If any sensor smoothing was performed during post-processing, the user may choose to apply the smoothed heave, roll, and pitch sensor values during SV Correct.

Note: Choosing the smooth sensor option will not affect survey data if smoothed coefficient data are not present. The unsmoothed sensor data will be applied by default.

FFR is very important to the beam forming process for MBES systems that use flat-faced transducers, and OCS recommends this process be performed during data acquisition. However, for certain Simrad and Elac flat-faced multibeam transducer types, HIPS is capable of performing FFR during post-processing.

For Simrad, FFR can be performed in HIPS if beam range and beam angle datagrams are present in the raw data. (Simrad EM data logged in Simrad Merlin/SIS RAW.ALL format includes the necessary datagrams; EM data logged in HYPACK HYSWEEP format does not.) A check box in the HIPS SV Correct dialog to "Perform an additional recomputation of the steered beam angles based on a new surface sound speed that will be interpolated from the sound velocity profile" controls whether or not HIPS will attempt FFR.

For Elac, FFR is automatically controlled by the presence or absence of Surface Sound Speed (SSP) sensor data. If SSP data have been logged in the raw Elac data, the HIPS converter will extract it to the HDCS data. The presence of SSP data in the HDCS data implies that a sound speed probe was utilized during data acquisition and, hence, no re-application of FFR need take place (the preferred method). If SSP data is not present in the HDCS data, SV Correct will automatically perform FFR.

Note: The actual SSP data is used for no other purpose than turning Elac FFR on/off during SV Correct.

If data quality issues dictate that FFR be performed during SV Correct, any SSP files present in the HDCS data must first be manually deleted. (Refer to section 4.1.1.1.1 for important details regarding HVF settings pertaining to Elac FFR.)

Beam ray-tracing is performed on all MBES data during HIPS SV Correct, regardless of echosounder type. Starting from the initial launch angle (reported or otherwise FFR-corrected), each sonar beam within a given survey line is processed as a ray refracting through the loaded sound speed profile and tracing a non-linear path. The distance of this path is assumed equivalent to the measured one-way travel time for the beam. By calculating a more precise one-way travel time, a more accurate beam position and depth can be determined.

Typically, a concatenated SVP file (generated by NOAA's Velocwin software) that contains multiple sound speed profiles, complete with metadata to indicate when and where observations took place, will be applied to survey data. In such cases, the user will need to choose a method for selecting how individual sound speed profiles are applied. HIPS SV Correct provides four options: previous in time, nearest in time, nearest in distance, nearest in distance within time. The method selected should be whichever will most accurately represent survey area conditions.

4.2.3.5 Merge

The HIPS Merge process calculates "Processed Depths" (latitude, longitude, depth) by compensating "Observed Depths" (alongtrack/acrosstrack position and depth with respect to the vessel RP) for heading, navigation, and tide data. Merge will also apply vessel attitude, waterline, and dynamic draft if the data were not previously processed with SV Correct.

Note: the "Apply" box must be checked for waterline, dynamic draft, and each attitude sensor in the HVF for these data to be applied.

The HIPS Merge tool can determine what corrections have been applied during SV Correct and will not perform a double correction for these sensors.

If any sensor smoothing was performed during post-processing, the user may choose to apply smoothed sensor values during Merge.

Note: Choosing the smooth sensor option will not affect survey data if smoothed coefficient data are not present. The unsmoothed sensor data will be applied by default.

The "Apply Refraction" option in Merge controls whether or not any refraction adjustment saved using Swath Edit's Refraction Editor will be applied. Refraction coefficients for this process are manually determined by the user during Swath Edit processing (see 4.2.4.3.2) and are stored in each survey line folder.

If no "refCoefficient" files have been created, the "Apply refraction coefficients" option will have no effect on the data.

Since OCS has not operationally implemented surveying on the ellipsoid, the "Apply GPS tide" option in Merge shall not be used for processing data for submission. See 4.2.3.2.1.

4.2.3.6 Compute TPE (Total Propagated Error)

Prior to data processing, vessel offsets and total propagated uncertainty (hereafter referred to as Total Propagated Error, or TPE) values based on uncertainty estimates for survey equipment should have been entered into the corresponding HVF (see CARIS HVF Uncertainty Values.pdf in Appendix 4).

Note: Although often referred to as TPE, we are really concerned with the uncertainty of the component measurements and therefore the total estimate of a sounding's uncertainty (i.e. Total Propagated Uncertainty, or TPU). Hydrographic subject matter experts are beginning to refer to a sounding's uncertainty as TPU, and no longer TPE. However, CARIS still refers to TPE in their documentation and software, so CARIS terminology will be used when referring to the CARIS procedure "Compute TPE".

For the most part, uncertainty estimates entered into the HVF file are static over a field season or in the absence of changes to the vessel configuration. Some HVF uncertainty estimate values may need to be adjusted on a case-by-case basis to account for any un-modeled uncertainty in a given component of the sounding. For example, in areas with strong currents, uncertainty in vessel speed can be adjusted in the sensor TPE section of the HVF to compensate for appreciable differences between speed-over-ground and speed-through-water. Another critical example of TPE values that may need to be updated in the CARIS HVF is depth uncertainty introduced by heave in singlebeam data acquired on vessels without an attitude sensor. Survey days with substantial heave introduce a larger depth uncertainty than calm days, and require a larger TPE value in the heave section of the HVF. An estimation of uncertainty introduced by heave can be calculated by multiplying the heave amplitude (1/2 the wave height) by 0.707. (This formula is equal to 1 sigma of a sinusoidal wave).

Most of the uncertainty estimates that are entered into a CARIS HVF are straightforward and are based on direct measurement techniques or manufacturer provided information. The estimation of the uncertainty value associated with MRU alignment is an exception. There is no direct method to measure or estimate MRU alignment uncertainty. One method to estimate these values is to calculate the standard deviation of a large sample of angular bias values resolved with a patch test. The sample size can be created either by a number of people resolving the angular biases or a couple of people resolving the values numerous times. Angular bias values resolved in a patch test are actually a measurement of the angular bias that exists between the transducer reference frame and the MRU reference frame. Therefore, any uncertainty values derived from the patch test angular biases are based on the same relationship. As it is the angle between the MRU and the transducer that we are measuring, rather than the absolute alignments of both the MRU and the transducer to a vessel reference frame, we can assign this uncertainty to either the MRU alignment or the transducer alignment. CARIS expects this value to be entered into the MRU alignment uncertainty field.

Note: All changes made to HVFs used to process OCS hydrographic survey data shall be approved by the field unit's Chief-of-Party and completely described in the Descriptive Report. Provided the TPE sensor values in the HVF do not require modification as noted above, TPE computation for specific survey lines is completed by selecting a set of survey lines and choosing the Compute TPE process in HIPS. Once the process has been selected, uncertainty values that change on a survey-by-survey basis, such as tide and sound speed, are entered into the Compute TPE dialog box.

Previously, tide and sound speed uncertainty values were entered into the CARIS HVF with the horizontal and depth uncertainties. Recent CARIS HIPS versions require tide and sound speed uncertainty values entered into a separate dialog box instead of being stored line-by-line. These values were separated out from the HVF on the principle that these values only changed according to survey location. Recent research has shown, however, that there may be multiple tide and sound speed uncertainties for a given survey. HSTP and the Center for Coastal and Ocean Mapping Joint Hydrographic Center (CCOM-JHC) have projects underway to come up with a procedure and tools to more consistently assess sound speed uncertainty in a survey area. The current process, in the meantime, shall be to enter a sound speed uncertainty value on a survey-wide basis (at BASE surface creation).

An example of the CARIS uncertainty estimate dialog box is given in Figure 4.9 .

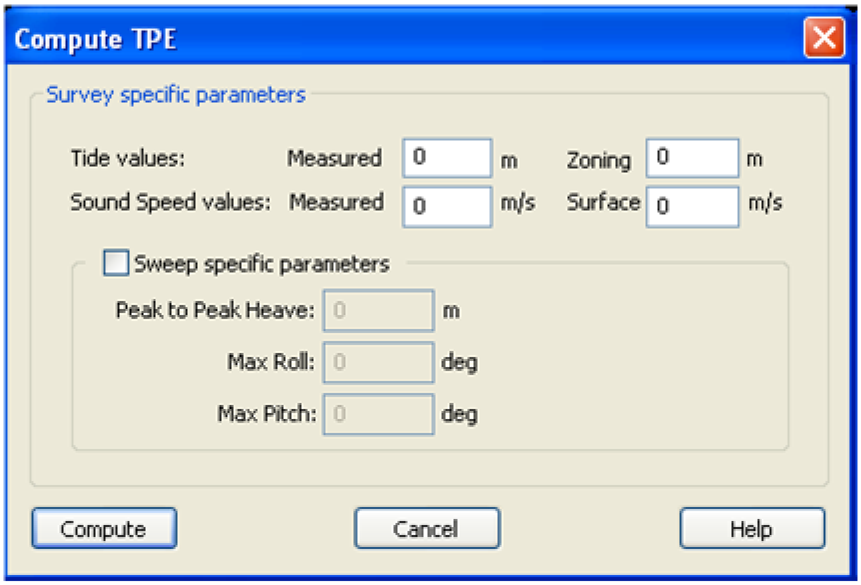

Figure 4.9: HIPS TPE dialog window

Tide zoning uncertainty values for discrete zoning are based on error values provided by CO-OPS in the tide requirements document provided on the project CD. These varying accuracies and unquantified uncertainties of tide correctors resulting from discrete zoning could have a potential impact on computing TPE The Tide Component Error Estimation, which is section 5.8.1.3 of the requirements document, provides a zoning error at the 95% confidence level. All error values entered in CARIS are assumed to be 1 sigma, and thus the value provided by CO-OPS should be divided by 2 to approximate the required 1 sigma error level. Tide zoning uncertainty values for TCARI are still being developed and will be provided in the near future.

The sound speed component of total propagated uncertainty is a function of environmental variability with respect to space and time and instrument/calibration uncertainty. Of the two, environmental variability has the greatest influence. Sound speed has a complicated dependence on salinity, temperature and pressure with the greatest change in acoustic propagation speed occurring with the change in temperature between the surface and the lower limit of the thermocline.

HSD has determined that the measured sound speed uncertainty may range from 0.5 to 4 m/s. This range depends on the spatial and temporal environmental variability and the frequency at which sound speed casts are taken. Casts taken at a high frequency (i.e. every 15 minutes or less) will capture the spatial variability better and lower the uncertainty values. HSD requires platforms to use the measured uncertainty values (i.e. TPE) for sound speed listed in the CARIS HVF Uncertainty Values.pdf in the Appendix 4.

Field Units should note the 4 m/s uncertainty estimate (listed in the table from HTD-2 and HTD-10) for traditional sound speed casts is a conservative estimated variability value determined via Velocwin. Hydrographers can lower this uncertainty by increasing the number of casts for a given areas. Thus, field units are strongly encouraged to utilize a high frequency cast system (e.g., MVP) whenever possible and especially in highly variable areas.

Sound speed error estimation is the subject of continuing investigation at UNH CCOM/JHC, and an algorithm to estimate this value more accurately using temporal and spatial separation between the sound speed profiles and soundings is under development. An algorithm has been developed by HSTP which allows field units to use observed data to estimate the sound speed uncertainty for each project area. This algorithm was operationally tested in Fall 2007, and HSD hopes to make this available to as many platforms as possible mid-season 2008. See the Chapter 4 Appendices for the Sound Speed Uncertainty Estimator SOP. Field units which have not been trained in the proper use of this software should use the uncertainty values listen in the CARIS HVF Uncertainty Values.pdf in the Appendix 4 but are welcome to test out the program. All MBES platforms can expect to use this algorithm by the 2009 field season.

The TPE values associated with surface sound speed have a smaller range and magnitude than measured sound speed (0.2 m/s to 2 m/s) because sound speed is continually measured at the transducer. The sound speed uncertainty, therefore, is dictated by the sound speed gradient at the velocimeter's sensor head.

If field units wish to deviate from the sound speed uncertainty values listed here, a review of the variability in the surface sound speed will be necessary to estimate the sound speed uncertainty for a given survey. If the field unit can prove through detailed documentation and calculation that their calculated uncertainty is lower than those stated in the CARIS HVF Uncertainty Values.pdf (see Appendix 4), then the lower value may be used. As with any deviation from procedures specified in the HTD's, FPM or the HSSD, methods for estimating uncertainty, and justification for this deviation, should be clearly described in the Descriptive Report as well as the Data Acquisition and Processing Report. The field should be aware, however, that if the processing branches disagree with the method used, any corresponding surveys using these uncertainty values may be returned to the vessel. Therefore, HSD strongly recommends that field units communicate to the branch their proposed approach. If the branch feels the method is adequate, a detailed description of the method, corresponding calculations and data will need to be sent to HSD for verification (and dissemination to other field units if approved).

NOAA does not currently conduct sweep surveys, and the lower section of the TPE dialog box is not utilized.

The TPE values for each sounding (σV and$\hat{\sigma H}$, see propagated uncertainty equation in 4.1) will be computed at the 95% confidence interval.

4.2.3.7 Filter

Depending upon data quality, the hydrographer may choose to filter a dataset during post-processing. HIPS provides several filtering tools that can be used to automatically flag data as rejected or accepted. Filtering methods commonly used for processing OCS hydrographic survey data include TPE (see section 4.2.3.6), sonar quality flags, angle from nadir, and depth threshold. The TPE filtering option can be used to expeditiously reject soundings with uncertainty values that fall outside limits set for either an IHO order survey or some user-defined parameter. However, the hydrographer should keep in mind that it is the grid node depth that must meet survey specifications, not each individual sounding. Thus, the TPE filtering tool may over clean data. MBES data can be filtered based on sonar quality flags and/or angle from nadir. Although filtering by sonar quality flags is not recommended by OCS, filtering based on angle from nadir may be useful when external conditions cause outer beams to degrade to the point of being unusable. Both MBES and VBES data may be filtered based on depth threshold. This method can be used to eliminate anomalous soundings resulting from double-echoes or near-surface reflection such as propeller wash, entrained air, and marine life. Consult the

CARIS HIPS and SIPS User's Manual for more information on filtering methods.

4.2.3.8 Add to Coverage BASE Surface

A BASE surface model should be created to demonstrate data coverage in accordance with section 5.1.2 of the HSSD. Each day, newly acquired data should be added to this surface for a quick coverage assessment and planning of the next day's surveying operations. The hydrographer is reminded that AWOIS radii that extend beyond the basic survey limits must be entirely covered with 200% side scan, complete or object detection multibeam, or a combination thereof to be disproved by sonar data. These radii should be considered when evaluating survey coverage.

Coverage requirements will vary based on the classification of MBES data assigned in the Project Instructions. Three general classifications for NOAA hydrography are Complete Multibeam, Object Detection, and Set Line Spacing. Typically when a BASE Surface is created to evaluate coverage, that day's bathymetric data have not yet been analyzed using directed-editing processes. Thus, the coverage BASE surface may need to be re-gridded periodically to verify that subsequent editing did not affect data coverage.

When generating BASE surfaces, the amount of computer memory needed is a function of grid size and resolution; thus, depending on the geographic extent and bathymetric complexity of the survey data, more than one Field Sheet may need to be created.

4.2.3.8.1 Field Sheet and Grid Size Guidance Here is some practical guidance related to the size of field sheets within CARIS HIPS and SIPS:

- maintain less than 25 million nodes per grid. This can be achieved by staying beneath the following limits for physical grid size:

grid resolution (meters)	physical grid size (km^2)
0.5	6.25
1	25
2	100

- minimize vacant grid nodes ('white space')
- keep all grid file sizes between 300-500 Mb
- use 5 m grid for VBES data (we don't gain any value with any higher resolution for VBES data)

4.2.4 Boat-day Processing

"Boat-day Processing" as described in this chapter refers to that portion of hydrographic data processing that is performed on a single vessel's data that were acquired during a single day of data acquisition. Prior to commencing Boat-day Processing, all of the Daily Batch Processing tasks (4.3.3) should have been performed. For ships and launches, Boat-day Processing is typically accomplished during a "night processing" shift. For field parties, this processing step is often saved for foul weather days or is accomplished by a shore party member in charge of daily data processing.

Boat-day Processing is based on the natural interpretive power of the human eye to evaluate a BASE surface for anomalous bathymetry, directing attention to areas that require review and/or editing (i.e., “directed editing”) by an experienced hydrographer. Vertical exaggeration is a very useful tool to accentuate bathymetric features and artifacts on a “sun-illuminated” BASE surface. However, extreme depth scaling can make small features seem significant and/or make acceptable multibeam data appear riddled with problems. Scaling sun-illuminated depth layers by a multiplier of three to five is generally a good choice for initial data review. If artifacts are perceived, the hydrographer can measure the vertical distance of the artifact (peak-to-trough) and compare this distance to the allowable vertical error for the survey to determine if the data is acceptable.

Note: In navigationally significant areas where no supporting imagery data exist (see 4.3), special emphasis should be placed on the review and interpretation of bathymetry data and, as needed, supporting sensor time series data.

In most cases, data anomalies can be easily evaluated and edited using HIPS Subset Editor (see 4.2.4.3.1). However, complex areas may require additional line-by-line evaluation and editing via HIPS Swath Editor (see 4.2.4.3.2).

For VBES data that will not be incorporated into a BASE surface for analyses, several processing steps may be skipped. Once data are merged, the hydrographer should review attitude and navigation time series data as described in sections 4.2.4.3.3 and 4.2.4.3.4, then use the HIPS Single Beam Editor tool to review bathymetry data. Following this review, the most accurate water level data available should be applied (see 4.2.5.1), and then the VBES data can be inserted directly into Pydro.

Note: Data flagging can not be performed in HIPS Single Beam Editor, thus all bathymetry features from VBES data must be created and flagged in Pydro (see 4.4).

4.2.4.1 Create Boat-day BASE Surface

The first step in Boat-day processing is to create a CARIS BASE surface of the vessel’s daily data using final gridded data specifications as defined in section 5.1.1.3 of the HSSD. Initially the Boat-day BASE surface is used to direct the editing process (see 4.2.4.3). Once editing and the appropriate checks are complete the Boat-day BASE surface can be regridded and added to a Survey-wide BASE surface that will, ultimately, be finalized and submitted.

Note: When generating BASE surfaces, the amount of computer memory needed is a function of grid size and resolution; thus, depending on the geographic extent and bathymetric complexity of the survey data, more than one Field Sheet may need to be created. See4.2.3.8.1.

An option exists in the HIPS BASE surface creation process to add comments. These comments are included in the metadata stored in an XML companion file with every BASE surface. In addition to having metadata in a separate file, it is helpful to include some descriptive information in the BASE surface file name. The following BASE file naming convention is an effective way to keep track of Boat-day surfaces:

Registry Number_Vessel Number_Day-of-Year_Resolution_<Lettered Index>

For example, the names for two Boat-day BASE surfaces created at a 2 meter resolution using RAINIER launch #4 data from day number 152 might look like:

“H12345_RA04_152_2m_a” and “H12345_RA04_152_2m_b.”

An image color map must be selected for each BASE surface during the creation process. A color map should be chosen to highlight the full range of features found within the BASE surface. If the user does not like the color map chosen during BASE surface creation, the palette can easily be changed later via the HIPS “Image Designer” (see next section).

4.2.4.2 Review Boat-day BASE Surface

Once a Boat-day BASE surface has been created, it should be investigated for indications of data problems (artifacts) and features. A bathymetric feature is any object that may be of importance for nautical charting, such as a wreck, shoal, or other item that may need further investigation. Typically, the depth and standard deviation BASE surface layers are most useful for identifying data anomalies (see list of BASE attributes in 4.2.1.2).

The HIPS Image Designer can be used to assist the hydrographer with BASE surface review. This tool allows the user to customize a BASE surface color map and adjust the azimuth and elevation of simulated sun illumination. Varying these settings helps highlight artifacts and features that may be hidden when viewed using only one set of display parameters. The hydrographer should systematically inspect all BASE surfaces at least four times, moving the azimuth of the virtual sun 90° each time while maintaining a moderate to low elevation. For example, azimuth values of 045°, 135°, 225°, and 315° (northeast, southeast, southwest, and northwest) with a fixed elevation of 45° is a common, and usually effective, series of settings.

Note: If plotting BASE surfaces, a sun elevation of 45° and azimuth of 315° generally presents artifacts and features most accurately. A particular pixel-color can also be set as transparent. Choosing a transparent pixel of “0” will make the otherwise white background of the image transparent so that underlying data (charts, orthographic photographs, etc.) will be revealed.

Problems that may be encountered in a MBES data set can generally be broken down into the following seven categories: refraction, attitude, position, heading, sonar, environmental, and tide. Each of these data problems is described below. For further guidance on which tools should be used to edit various data problems, see 4.2.4.3.

4.2.4.2.1 Refraction Acoustic refraction-induced errors are caused when the speed of sound through the water column is not adequately modeled over time or space. When viewing data with refraction errors in the acrosstrack direction, the hydrographer will notice a “smiling” or “frowning” characteristic as shown in Figure 4.10 .

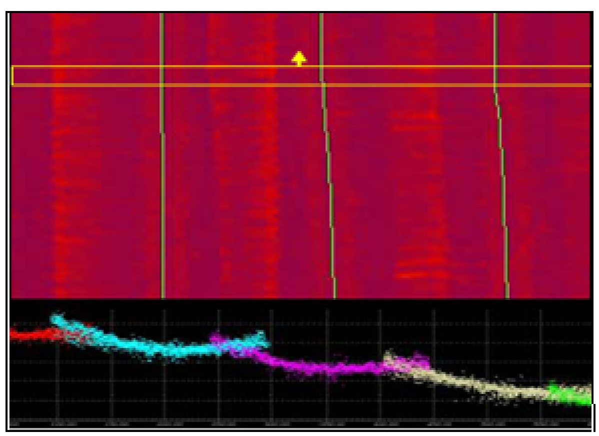

Figure 4.10: HIPS Subset Editor view (bottom) of acoustic refraction-induced bathymetry errors, using BASE surface standard deviation image for reference.

Depending upon the cause of this artifact, it may indicate a need for additional sound speed profiles each day or more profiles spatially over the survey area. Typically, the amount of time required to obtain additional sound speed profiles is far less than that required to edit, or otherwise “fix”, data afflicted with acoustic refraction artifacts.

HIPS Refraction Editor, a tool in Swath Editor, may be used to assist with troubleshooting refraction errors. Refraction Editor allows the user to enter a step sound speed correction at a specified water depth. As sound speed corrections are entered, the effect is reflected in the swath edit display by increasing or decreasing the curvature (smiling or frowning) of the swath.

Note: HIPS does not account for TPE (see section 4.2.3.6) introduced by using Refraction Editor; thus, Refraction Editor is not approved for use in OCS hydrographic surveys and shall not be used for deliverable products.

4.2.4.2.2 Attitude Vessel motion artifacts may arise due to a failing accelerometer within the heave/pitch/roll sensor, a gap occurring in data transmission or recording, an inaccurate patch test (e.g., conducted in insufficiently deep water for the given survey area), or unaccounted latency within the data acquisition system. An example of a gap in the recorded attitude time series is illustrated in Figure 4.11 .

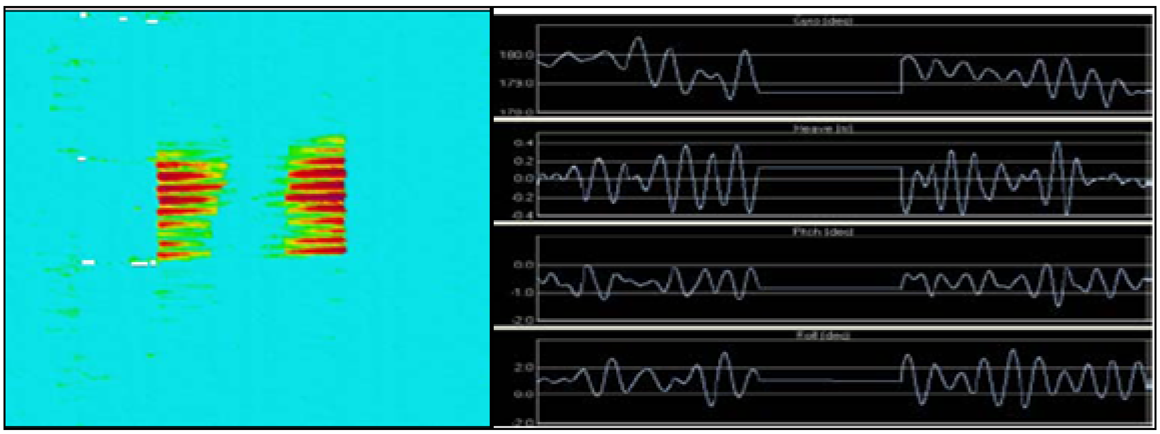

Figure 4.11: BASE surface standard deviation layer (left) of a survey line with data gap in attitude time series (right).

If a specific cause of vessel motion artifacts can be determined, it may be possible to repair the data. For example, a new patch test could be run, or data could be reprocessed to account for a known latency. In other cases, data may need to be either smoothed to minimize the artifact or rejected entirely. If systematic errors are found in a vessel's attitude data, the time spent trouble shooting the source of the problem will typically far outweigh the time required to continually edit data.

4.2.4.2.3 Position Gross horizontal positioning errors are uncommon when using modern surveying equipment. Inertially-aided GPS navigation equipment, such as the Applanix POS/MV, uses Kalman filtering to constrain vessel speed, acceleration, and displacement, eliminating the majority of potential positioning errors. The most common cause of error in an inertially-aided system is when the GPS portion of the position solution fails.

Note: Due to the horizontal position accuracies required for OCS hydrographic surveys, loss of differential GPS corrections should also be considered GPS failure. The effects of temporarily losing differential corrections are illustrated in Figure 4.12 .

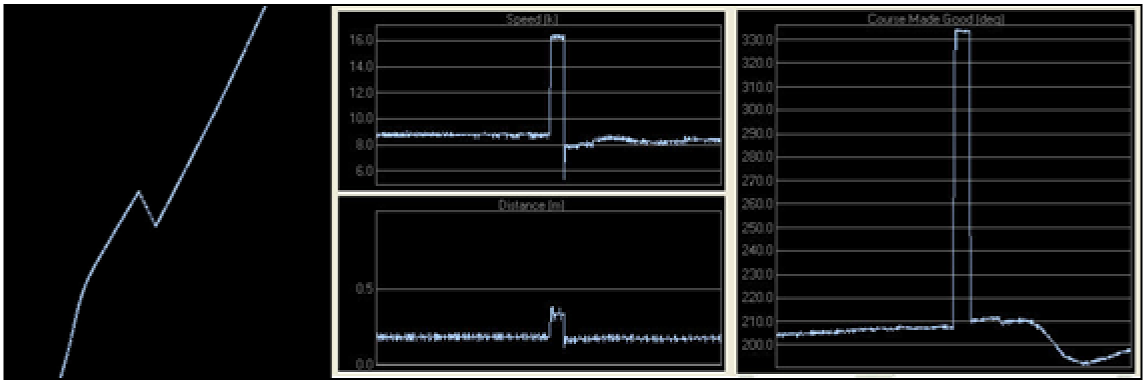

Figure 4.12: HIPS Navigation Editor time-series showing positioning error caused by temporary loss of differential corrections. This effect may also be caused by switching the frequency of the differential beacon receiver.

During a GPS failure, inertial navigation systems can dead reckon for approximately 30 seconds before errors accumulate to a level that produces unacceptable positioning. The hardware/software interface for an inertial navigation system should be configured to alert the user of failure events so that data acquisition can be suspended if position data becomes unacceptable.

Positioning "problems" associated with horizontal uncertainty may be seen on areas of extreme slopes. For example, if the horizontal accuracy is approximately 4 meters, the vertical depth error on a slope of 60° would be almost 7 meters. Inconsistencies will be observed from swath to swath in these areas due to the horizontal positioning error. Keep in mind that horizontal uncertainty is factored into the BASE node uncertainty calculation, and may adequately account for what appears to be positioning errors on steep slopes (see 4.2.1.1).

4.2.4.2.4 Heading Heading errors can be induced by a faulty sensor or an incorrect heading alignment correction entered in the HVF. This problem can be easily identified as a break in continuity of linear features from one swath to the next.

During data acquisition, heading values are sometimes included in datagrams from sensors other than the primary navigation system. However, the accuracy of heading data will vary depending upon its source. If heading errors are discovered, it may be possible to re-process the data using heading information from another source. The field unit's FOO or equivalent should be notified if an alternate heading source (e.g., calculated course-over-ground) is used to process survey data, as TPE (see section 4.2.3.6) values in the HVF may require editing.

4.2.4.2.5 Sonar Sonar-induced data problems are typically caused by inappropriate settings in the sonar system. These may include unoptimized power, gain, and threshold settings, as well as improper range settings for the depth of water. Any of these circumstances could prevent the sonar from accurately representing the sea floor. The best way to minimize sonar-induced errors is by having a well-trained and attentive operator during data acquisition.

4.2.4.2.6 Environmental Environmental data problems are those caused by objects or disturbances in the water column, such as marine life, vegetation, entrained air from passing vessels, or weather-induced disturbances from heavy seas or rain. Figure 4.13 shows an example of environmental noise which occurred near the transducer face.

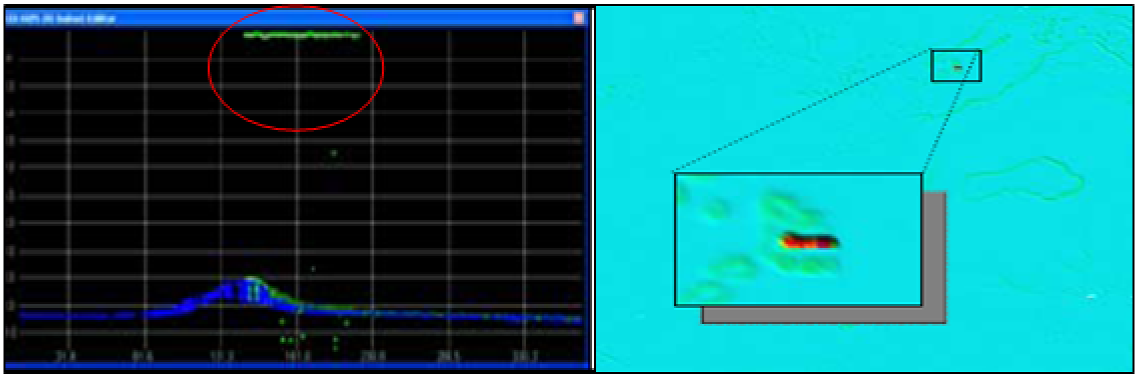

Figure 4.13: HIPS Swath Editor view (left) and BASE surface standard deviation layer view (right) showing water column noise near transducer.

As with all data problems, environmental data issues are most effectively addressed during the acquisition stage rather than during processing. Depending upon the severity of data problems, acquisition may need to be suspended until environmental conditions have improved.

4.2.4.2.7 Tide Tide errors can result from inaccuracies in any of the source data used in the vertical datum transformation algorithm, such as inaccuracies in the water level observations, tide zoning model, or navigation. This type of error is often identified by a measurable vertical offset visible when data are viewed in the acrosstrack direction, as shown in Figure 4.14 .

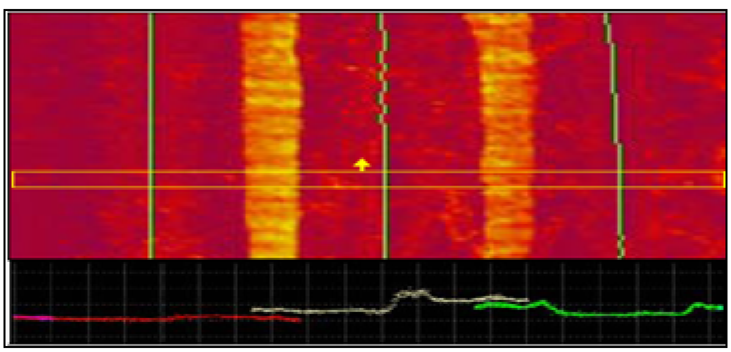

Figure 4.14: HIPS Subset Editor view of tide-induced bathymetry errors (bottom), using BASE surface standard deviation image for reference (top).

If tide errors are identified, the hydrographer should ensure that the correct water level data have been loaded for the suspect dataset. Keep in mind that predicted tide files do not account for water level effects due to non-astronomical forces. Thus, what appears to be a data problem may correct itself once observed water level data are applied. However, the varying accuracies and unquantified uncertainty of tide correctors resulting from discrete zoning have the potential to result in tide-induced bathymetry errors even when using actual tide gauge data rather than predictions. If there are no other hydrographic sources of this error, this would indicate that either the tide gauge locations are inadequate and/or the method of discrete tidal zoning cannot account for the complex hydrodynamics of this survey area.

4.2.4.3 Directed Editing from Boat-day BASE Surface

One or more of the HIPS data “editors” can be used to analyze data artifacts and features of interest that are identified on the Boat-day BASE surface. With the exception of VBES data, depth values cannot be directly edited or changed in HIPS; rather, soundings can be flagged with various attributes, including “rejected” which will suppress a sounding from further processing steps. Daily review and flagging of features is strongly recommended to maintain an organized and complete survey. Supporting sensor data can also be flagged as being rejected, either with or without interpolation.

Subset Editor is the most frequently used HIPS editing tool and allows the most flexibility in addressing a problem that is concentrated in one geographic area. OCS recommends the use of “Subset Tiles” with 10% overlap to track editing progress in Subset Editor. Once defined, subset tiles may be flagged as either “Complete” (green), “Partially Complete” (yellow), or “Incomplete” (red) to identify areas that have been investigated, need a second review, or have not yet been edited, respectively.

In some cases, it may be beneficial to review individual sonar pings in a specific line of survey data. This type of line-by-line editing can be performed in HIPS Swath Editor. If potential problems in either attitude or position data are noticed, the Attitude Editor or Navigation Editor tool can be used to review individual sensor time series data. Each of these four data editing tools is described in greater detail below. Refer to the CARIS HIPS and SIPS User’s Manual for further information on any of these tools.

4.2.4.3.1 Subset Editor Subset Editor enables the hydrographer to review and edit a “subset” of the entire sounding dataset, and corresponding BASE surface data, by geographic area. Subsets are rectangular in shape and will contain all soundings acquired within the geographic boundaries of the subset. Subsets can be created in a north-south or a rotated orientation. Rotating a subset can be useful to obtain a profile view when inspecting data along slopes or dredged channels.

When using Subset Editor, the hydrographer should be aware of the data display settings, particularly vertical exaggeration and whether rejected soundings are displayed. If vertical exaggeration is set to “Auto,” then the display will rescale as soundings are edited. This feature creates a potential for the user to become focused on very fine details in the seafloor and essentially edit data to create a smooth bottom, which rarely exists. The hydrographer must take care not to “over clean” data in this fashion. Displaying rejected soundings allows the user to see data that has been previously rejected, typically by a filtering routine in Swath Editor or editing by another hydrographer. Viewing rejected data is often valuable when investigating the validity of a possible feature.

Individual soundings or groups of soundings may be selected and flagged in Subset Editor. Available data flags and each flag’s purpose with respect to OCS hydrography are as follows:

- Reject - Flag anomalous soundings as “rejected” to suppress them from being included in subsequent processing steps, such as in the calculation of BASE surface grids.
- Reject Swath - This flag sets the “rejected” flag for all soundings in a selected swath. Use this function to reject a single ping or a continuous section of flawed sonar pings.
- Outstanding - This flag may be set for any data point that holds particular hydrographic significance. Typically, if the identity, extent, or validity of a feature is uncertain, it should be flagged as “outstanding.” NOAA Pydro software treats soundings flagged “outstanding” in HIPS as bathymetry features. Pydro establishes a connection to the HDCS data for all “outstanding” soundings and will automatically update the HDCS data for any subsequent flag changes made in Pydro during feature processing (see 4.4).

◦ Examined - This flag does not currently have a defined meaning for OCS hydrographic survey data; however, it can be used by the surveyor as a means of marking a sounding for future reference. This flag can also be used to separate a group of soundings for non-standard data analyses.

◦ Designate - Applying the “Designate” flag to a sounding will force the BASE surface grid node closest to that sounding to assume the exact depth value of the designated sounding, ignoring all other soundings within the area of influence of this node. Pydro regards soundings flagged “designated” in HIPS as “designated” bathymetry features in Pydro. Pydro establishes a connection to the HDCS data for all “designated” soundings, and subsequent flag changes or edits made to the bathymetry feature in Pydro will automatically be reflected in the HDCS data.

◦ Find and Designate - This tool will automatically flag the shoalest sounding in a user-selected group as “designated.” If only one sounding is selected, Find and Designate is equivalent to Designate.

4.2.4.3.2 Swath Editor Swath Editor enables the hydrographer to review and edit a single swath of data from four orthogonal directions as well as from a three dimensional perspective.

Note: Data viewed in Swath Editor are not geo-referenced, but displayed with respect to acrosstrack and alongtrack distances from the transducer.

Data problems that appear to be limited to the extent of a single line of data are often best addressed using Swath Editor. As when using Subset Editor, individual soundings or groups of soundings may be selected and flagged in Swath Editor. HIPS data flags and their purpose in OCS hydrography are described in 4.2.4.3.1.

Note: “Outstanding” and “Examined” flags can not be applied using Swath Editor.

Swath Editor also allows the user to view amplitude (i.e., backscatter or side scan) data from a multibeam echosounder. Amplitude data can provide valuable insight for determining if a particular sounding or group of soundings is a real feature.

Note: Side scan data may also be viewed in CARIS SIPS Side Scan Editor. Backscatter can not.

4.2.4.3.3 Attitude Editor Attitude Editor allows the hydrographer to review and edit heading (gyro), heave, pitch, and roll data. Attitude Editor displays each sensor’s time series data for a single survey line. HIPS provides three means of editing attitude data, rejecting (with or without interpolation), filtering, and smoothing.

For data problems of limited extents in time, rejecting is generally the preferred editing method. There are two options for rejecting attitude data: “Reject-with interpolation” and “Reject-break interpolation.” Rejecting data with interpolation will fit a straight line from the last good data point before the segment rejected to the first good data point after the segment rejected. Caution should be exercised when using this tool. Rejecting and interpolating sections of attitude data across the peaks of a signal will result in distorting the maximum observed amplitude at that time, as illustrated in Figure 4.15 .

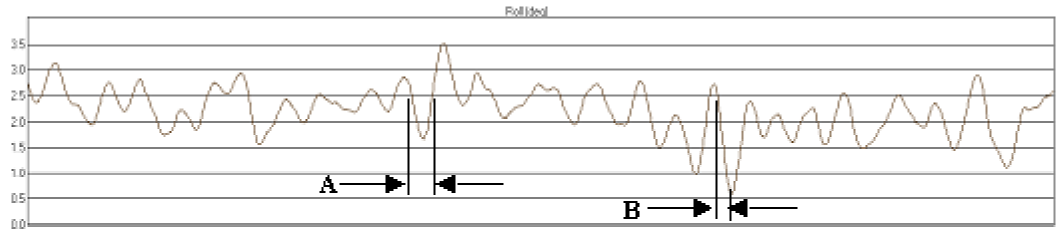

Figure 4.15: Interpolation across region 'A' will most likely create an artifact of its own, whereas interpolation across region 'B' will not adversely impact the sounding data

Rejecting without interpolation should be used to edit attitude data corruption occurring over an extended period of time. A general rule of thumb is to divide the allowable data gap distance for the survey by the vessel speed in meters-per-second to determine when to begin breaking interpolation. For example, if a 5 meter resolution grid is required to demonstrate adequate data coverage and the vessel speed is 5 m/s (~10 knots), regions of bogus data greater than or equal to 1 second (5 m ÷ 5 m/s = 1 s) should be rejected without interpolation. The Hydrographer should note that breaking interpolation will create a gap in the data. When the files are merged, this option rejects all sounding data recorded during the time period in which sensor data were rejected, thus leaving a holiday in data coverage.

For attitude data problems that are systematic throughout the time series, filtering or smoothing is typically the best editing approach. The hydrographer is cautioned that filters are powerful tools and should be used sparingly and with great care. Attitude Editor provides two filtering options: "Moving Average" and "Fast Fourier." The Moving Average option calculates a mean for each data point according to a user-specified number of neighboring data points (in time or number) or "box size." The Fast Fourier method performs low-pass filtering on the sensor data according to a user specified signal period (in time or number-of-points).

4.2.4.3.4 Navigation Editor Navigation Editor allows the hydrographer to review and edit the vessel's navigation time series. The navigation time series can be edited in HIPS using rejection with or without interpolation. When rejecting data, the Navigation Editor tool offers two interpolation methods: Linear and Bezier. Linear interpolation is suitable if the majority of navigation positions are clean and do not deviate significantly from neighboring positions. Bezier interpolation is suitable if the original data is noisy. Linear interpolation simply calculates new positions over the rejected segment by connecting bounding positions with a straight line. Bezier interpolation calculates new positions over the rejected segment by fitting a Bezier curve through bounding positions, producing a resultant curve that may not necessarily connect or pass through all navigation positions on the line.

To help expedite data inspection, Navigation Editor provides "spike detection." This tool will search the navigation time series for user-defined "jumps" in speed and time. Each jump will be highlighted so that the hydrographer can decide how best to edit the data. Large jumps in speed, calculated as distance traveled divided by time between fixes, can detrimentally affect the vessel's dynamic draft computation. Data artifacts due to speed jumps will be more pronounced if the slope of the vessel's speed versus dynamic draft is steep. A general rule-of-thumb is to interpolate speed jumps if they exceed the TPE (see section 4.2.3.6) modeled for vessel speed in the HVF, but this becomes less critical if a vessel's speed versus dynamic draft slope is small. Since speed and time jumps are directly related and speed is used to determine dynamic draft, it is not necessary to separately edit time jumps.

4.2.4.4 Update Survey-wide BASE Surface

Once directed editing has been completed, the Boat-day BASE surface should be recomputed to verify that all edits were successful. If no further editing is necessary, the Survey-wide BASE surface should be updated, using final gridding parameters, to reflect the current survey status.

4.2.5 Survey-wide Processing

“Survey-wide Processing” includes many of the steps and skills discussed previously in this chapter. The difference is the context in which these steps are accomplished. During Boat-day processing, a single “boat-day’s” worth of bathymetric data is being viewed, edited, and flagged for internal consistency, gross errors, and any features that warrant further investigation. During Survey-wide processing, survey bathymetry and imagery data are examined in context with existing chart information and any additional supporting data available.

Many of the steps involved in processing hydrographic surveys are iterative and may be conducted in parallel with each other. Efficiency can be increased by conducting many of the Survey-wide processing steps concurrently with Boat-day processing for global quality control and general survey completeness. These processes would include verifying adequate investigation of charted features within the survey sheet limits, reviewing the data for DTONs, and verifying that data coverage meets the assigned specifications. Reviewing these points on a daily basis will help to ensure a complete survey and a timely submission.

4.2.5.1 Apply Water Levels

Preliminary water levels are 6-minute water level measurements that have undergone rudimentary data consistency checks in the CO-OPS Data Processing and Analysis System (DPAS). Any gaps in data coverage will remain in these preliminary data, and measurements may, or may not, have been reduced to the local MLLW datum. Preliminary water levels should be available within hours, if not minutes, of data acquisition. Verified water levels have gone through CO-OPS’ processing, analysis and quality assurance processes, and any gaps in data have been recovered or interpolated through a process which utilizes nearby gauge data. After a preliminary or accepted datum has been computed, 6-minute verified water levels are made available referenced to MLLW.

Note: Field units shall submit, via email, a Request for [Smooth] Tides to smooth.tides@noaa.gov within 24-hours of completing data acquisition for a survey (see 5.2.3.3.4).

Once a Request for Tides is received, CO-OPS will review the survey tide requirements to determine if adjustments or corrections are required. If CO-OPS needs to make any modifications, they will provide final water level correctors to the field unit. If no changes are required, CO-OPS will provide the field unit with an official smooth tide note stating that preliminary zoning, (and associated .zdf file) will be accepted as the final zoning; thus, verified water levels applied using preliminary zoning will be equivalent to final water level correctors. CO-OPS should respond to the field unit within two weeks of receiving a Request for Tides.

Verified 6-minute water levels and final water level correctors should be applied as soon as these data are available. See 4.2.3.2 and 4.2.3.5 for details regarding the application of water levels in HIPS.

4.2.5.2 Assess Bathymetry Features

Throughout the survey process, bathymetric contacts should be periodically assessed and a determination made as to whether "development" is necessary. Developing a bathymetric contact typically refers to acquiring additional MBES data over the feature to increase sounding density and determine, or verify, a least depth. However, other methods of obtaining a least depth may be used, such as VBES or DLDG.

Bathymetric contacts are often easily identified and corresponding HDCS data can be flagged during examination of the BASE surface depth or standard deviation layers. Soundings flagged "examined", "outstanding", or "designated" can then be highlighted using the HIPS "Display Critical Soundings" command. However, bathymetric features should also be assessed in Pydro, which enables the hydrographer to analyze each item in context with other available data sources such as the chart, imagery data, DPs, and AWOIS records/search radii. (Refer to 4.4 for additional details.) Within Pydro, the hydrographer can easily evaluate bathymetric features to determine if any are DTONs. Comparisons should also be made between sounding data and existing charted depths. If survey soundings indicate deeper water than the charted depth(s), the charted depth should be treated as a feature and additional data acquired, as necessary, to verify that the charted depth is incorrect. (This process is often referred to as a charted sounding investigation.) Bathymetric features should be evaluated for significance and data coverage and, if appropriate, flagged within Pydro for "investigation," as detailed in 4.4.

4.2.5.3 Review Survey-wide BASE Layers

The final Survey-wide BASE surface to be submitted shall be created in accordance with section 5.1.1.3 and 5.1.2 of the HSSD. Prior to finalization, BASE layers should be reviewed to ensure that the gridded surface truly reflects the conditions in the survey area, meets specifications assigned in the Project Instructions and that all features have been adequately investigated.

4.2.6 Finalize Bathymetry Data

For survey submission, BASE surfaces must be finalized in HIPS. This process is explained in detail in the CARIS HIPS and SIPS User's Manual. Finalizing BASE surfaces serves three purposes:

- To apply Designated soundings: In some instances, due to the nature of the weighting algorithm, a BASE surface does not accurately represent the least depth of a navigationally significant feature (typically a fine item such as a tall, narrow coral head or a shipwreck's mast). In such cases, a sounding can be flagged as Designated to force the nearest BASE surface grid node to honor the depth of the designated sounding. Refer to the following subsection for guidance on selecting Designated soundings. Designated soundings are applied to the BASE surface during the Finalize step in CARIS by checking the "Apply designated soundings" option.
- To assign grid nodes a final uncertainty: A grid node's final uncertainty can be assigned as one of three options: 1) that node's a priori uncertainty-weighted uncertainty, i.e., predicted error, 2) the grid node's standard deviation scaled to a 95% confidence interval, i.e., observed error, or 3) the greater of the two. For OCS hydrographic survey data, the "greater of the two" option shall be used to maintain a conservative uncertainty estimate.
- Define depth thresholds: A single-resolution grid will generally not be appropriate for an entire survey area. To maintain the optimal resolution for a given depth range, the finalize process filters out a desired depth range for each different grid resolution created.

4.2.6.1 Designate Bathy Features

Since the calculated depth at each grid node of a BASE surface is influenced by multiple soundings, the least depth of a feature may not always be accurately represented in the gridded data. Prior to creating a finalized BASE surface collection, the hydrographer must systematically review significant feature least depths to ensure they are accurately portrayed by the BASE surface.

If a specific least depth sounding is preferred over the weighted mean-depth calculation for the associated BASE surface grid node, that sounding should be flagged Designated. The Designated flag can be applied in either HIPS or Pydro. If a sounding is made Designated in one software package, this flag will automatically carry through to the other application. Designated soundings shall be selected in accordance with section 5.1.1.3 and 5.1.2 of the HSSD.

However, OCS recommends designating the least depth of every feature with special cartographic significance for easy identification and tracking.

4.3 Imagery Processing

NOAA hydrographic field units typically acquire three types of imagery data: side scan sonar (SSS), MBES backscatter, and MBES “side scan” which is available as an option on some systems. True side scan sonars produce superior imagery for object detection purposes and are used to meet object detection requirements for OCS hydrographic surveys.

Note: Backscatter data and side scan imagery acquired in conjunction with MBES bathymetry, is often processed as an aid for data analyses but is not approved by OCS for meeting hydrographic survey object detection requirements.

The procedures outlined in this section are required only for SSS imagery being used to meet OCS object detection criteria, and are not applicable to MBES imagery data unless noted as pertaining to a specific MBES system or “backscatter” data.

4.3.1 Imagery Object Detection

Imagery data are acquired and processed with the purpose of detecting objects that may be of navigational significance. This determination is typically based on contact type, position, and height above the sea floor estimated from the item’s acoustic shadow on the SSS record. Imagery data acquired for OCS hydrographic surveys are geographically referenced; thus, a position can be determined for each contact identified. The accuracy of this position will vary depending on whether the sonar was towed or hull-mounted, but either method should be sufficient to locate the item for further investigation. If a contact is determined to be significant, a “development” should be conducted to determine the item’s least depth and a more accurate position for charting.

4.3.2 Imagery Processing Flow Diagram

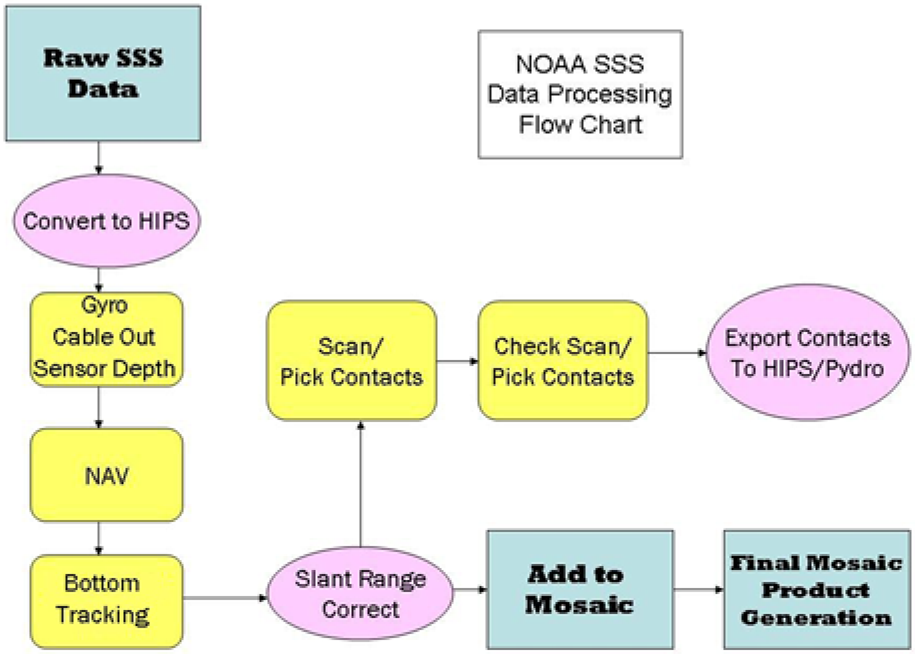

Figure 4.16: Basic data processing flow chart for SSS data.

4.3.3 Daily Batch Processing

Several processing tasks need to be performed on “raw” imagery data (i.e., unaltered data in the format generated by the acquisition software) before any detailed analysis and evaluation can occur. Some of these daily tasks are interdependent, and the specific sequence is critical. The recommended ordering of daily batch processing tasks is as follows:

1. Conversion 4.3.3.1
2. Filter, if applicable 4.3.3.2
3. Recompute Towfish Navigation 4.3.3.3
4. Slant Range Correction 4.3.3.4
5. Add to Mosaic 4.3.3.5

Most of the tasks above can be semi-automated in HIPS/SIPS using the “Batch Processor” tool. Data format determines how specific processing actions need to be configured; as such, a separate Batch Processing File (.hbp) is needed for each raw data format type.

In general, all of the aforementioned tasks should be completed for any type of imagery data being used to meet OCS hydrographic survey specifications. A basic set of batch processing files can be specified for each sonar type and reused on the appropriate set of survey lines acquired each day. In some circumstances, either creation of custom batch processing files or manual processing of one or more tasks, line-by-line, in non-batch mode may be necessary. For example, conversion and filtering options may need to be customized to reflect changes in sonar performance as weather conditions varied throughout a survey day.

4.3.3.1 Conversion

CARIS SIPS supports many different data formats that may be used to record imagery. During conversion, SIPS uses raw data to create files in CARIS' proprietary format which will be used in subsequent CARIS processing routines. These files in CARIS SIPS format are referred to as "SIPS files" or "HDCS files."

For towed SSS configurations, a calculated "towfish position" may have been recorded in the raw data depending upon the acquisition software being used. This calculation requires cable out and towfish depth (or water depth minus towfish altitude). If cable out and either towfish depth or water depth and towfish altitude were logged during acquisition, towfish position can be re-calculated during post-processing via SIPS Recompute Towfish Navigation (see 4.3.3.3). Either method of positioning should be adequate for standard SSS operations. However if re-computing towfish navigation, the hydrographer should first review and edit, if necessary, cable out and towfish depth. For hull-mounted configurations, sonar offsets should be accounted for in the HVF as vessel RP-to-towpoint values.

Note: Recompute Towfish Navigation must be performed for vessel RP-to-towpoint to be applied. For hull-mounted configurations (i.e., no cable out data recorded), towfish navigation will be recomputed using a cable out value of zero.

If an error is discovered in the HVF during SSS post-processing, re-conversion may not be required to correct the data. If unsure whether data repairs are necessary, the Survey Manager should consult, through his/her chain-of-command, the Hydrographic Systems and Technology Program for guidance.

The following sections contain guidance for converting common raw imagery data formats used by OCS into HDCS files. Relevant background information is provided, followed by a table of guidelines for specific Conversion Wizard settings related to each raw imagery format.

4.3.3.1.1 Elac (XSE) The SEABEAM 1050D and 1180 multibeam systems (Elac), used for bathymetric data acquisition as discussed in 4.2.3.1.1, are also capable of recording backscatter data. Elac backscatter imagery is generally poor in quality and is not an acceptable object detection method for OCS hydrographic surveys. These backscatter data may be useful for identifying changes in seafloor texture to guide bottom sampling operations.

Option	OCS Guidelines
Convert Side Scan	Choose this option and convert imagery data.

Table 4.9: OCS guidelines for converting Elac data.

4.3.3.1.2 Sensor Data Format (SDF) Sensor Data Format (SDF) may be used to store data from Klein System 3000 or Klein System 5000 side scan sonar systems. Conversion parameters will vary slightly depending upon the SSS system used to acquire the data. The SDF data format is generated by Klein Associates' proprietary software package SonarPro.

If data were acquired using a Klein 3000 dual frequency (100 kHz and 500 kHz) side scan sonar, the user must choose which frequency to convert. Choose the "high" option to convert 500 kHz data and "low" to convert 100 kHz data. Typically, higher frequency data will provide better imagery resolution, while lower frequencies travel further and can be used at larger range scales.

If data were acquired using a Klein 5000 dynamically focused multibeam side scan sonar, the user must choose whether or not to convert hidden beams. There are five beams on each channel (port and starboard) of the Klein 5000. Based on range scale and towfish speed, the system will determine the number of beams necessary to achieve 100% coverage. Typical range scales and speeds used for hydrographic surveying require that 3 - 4 beams be used. Selecting “convert hidden” forces all 5 beams to be converted and may improve imagery in high yaw-rate conditions (e.g., in turns or for hull-mount configurations) or aid in detection of very small objects during activities such as search and recovery. However, for the purposes of a basic OCS hydrographic survey, converting hidden beams is not necessary to meet survey specifications and can introduce data management problems by significantly increasing file sizes.

Towfish depth is used to calculate towfish navigation in SIPS. Both the Klein 3000 and 5000 systems are equipped with a pressure sensor installed in the towfish body to determine towfish depth. Each towfish will have a pressure sensor rated for 100, 300, or 1000 psi, depending on the anticipated operating depths. The hydrographer must know the pressure sensor rating for the specific towfish used to acquire data.

Both the Klein System 3000 and System 5000 towfish are equipped with a magnetic-based heading sensor. This sensor’s data are logged as SSGyro. Typically, a magnetic compass does not indicate true headings and must be corrected for magnetic declination (variation) and deviation to obtain a true heading. Electrical interference could also contribute to a loss of both accuracy and precision of the SSGyro. Due to these inaccuracies, OCS does not recommend using towfish heading sensor values (SSGyro) for processing survey data.

Various side scan sonar systems may record imagery at different resolutions. Both Klein System 3000 and System 5000 imagery data are recorded at a resolution of 12 bits. When converting SDF files, choosing an 8-bit conversion will reduce the data resolution. Even though the recorded resolution is 12 bits, choosing the option to “Preserve 16-bit” will retain the original resolution.

Options	OCS Guidelines
Klein 3000 Frequency - High or Low	High frequency data should be used unless range scale requirements are such that the higher frequency is ineffective.
Convert Hidden	Do not convert hidden beams as a standard practice.
Pressure Sensor - 100, 300, or 1000 psi	Choose the pressure sensor rating for the specific towfish used to acquire data being converted.
Convert SSGyro	Do not convert SSGyro.
16-bit Sonar Conversion - Preserve 16-bit - Convert to 8-bit: Scale or Shift	Choose to “Preserve 16-bit” resolution.

Table 4.10: OCS guidelines for converting SDF data.

4.3.3.1.3 Simrad Kongsberg Simrad multibeam systems, such as the EM1002 or EM3000, used for bathymetric data acquisition as discussed in 4.2.3.1.4, are also capable of recording backscatter data. Simrad backscatter imagery is not an acceptable object detection method for OCS hydrographic surveys. However, these backscatter data may be useful for verifying objects detected in bathymetry data or identifying changes in seafloor texture to guide bottom sampling operations.

Converting Simrad angle-dependent backscatter imagery into HDCS files is simple. When converting the Simrad bathymetry data in HIPS, the user simply makes a choice whether or not to "Convert Side Scan/Backscatter" data. No other choices are associated with imagery conversion.

Options	OCS Guidelines
Convert Side Scan / Backscatter	Choose this option and convert imagery data.

Table 4.11: OCS guidelines for converting Simrad data.

4.3.3.1.4 Extended Triton Format (XTF) The eXtended Triton Format (XTF) can be used to store data from a variety of side scan systems. Both imagery and bathymetry data from MBES systems can also be acquired in the XTF format, and the same CARIS XTF converter is used for all three data types. (Conversion parameters related to bathymetry data are discussed in 4.2.3.1.5.) XTF datagrams are comprised of a Triton-defined "header" attached to an optional manufacturer-specific sensor data packet. XTF is a common data format within OCS, primarily due to the widespread use of Triton Imaging's IsisSonar data acquisition software.

NOAA hydrographic field units acquiring SSS data with a Klein 5000 dynamically focused multibeam side scan sonar will typically log data in XTF format. Since the CARIS converter accommodates an extensive variety of sonar systems capable of logging XTF data, the user is required to make multiple decisions so that this raw sonar data is properly interpreted by CARIS. Each critical conversion choice is discussed below, with OCS guidance summarized in Table 20.

4.3.3.1.4.1 Convert Side Scan Some SSS systems, such as the Klein 3000, will simultaneously log data from multiple frequencies. During conversion, each frequency will be associated with a pair of sonar channels and the user must indicate which channels are to be processed. If the SSS operates on only one frequency, the data will always be associated with sonar channels 1 and 2.

Navigation data can be recorded in two separate datafields ("ship" navigation and "sensor" navigation) within the XTF side scan datagram. The primary difference between the "ship" and "sensor" fields is how the data is time stamped. "Ship" navigation is associated with the time logged in the XTF header, while each "sensor" navigation string is individually time stamped. Applying "Sensor" navigation is recommended to avoid potential timing errors.

Heading (gyro) data can not only be logged in multiple datagrams within the XTF record, but may also be recorded in multiple locations within the side scan datagram. While this sensor data may appear redundant, sources and data quality can vary. Typically, NOAA hydrographic field units will apply heading data stored in the "ship" field of the side scan datagram, which will correspond to the vessel's instantaneous heading. Heading data from the attitude packet will also correspond to the vessel's instantaneous heading, but the logging rate for attitude data is often set much higher than the update rate for heading. Thus, using attitude packet heading data will be effective but could be considered "overkill". If vessel crab angle is large and the SSS is being towed, the hydrographer should remember that a towed body will not be experiencing the same crabbing effect. In this scenario, course-made-good (CMG) from navigation often provides the best imagery. This option uses an interpolated heading value based on recorded vessel position fixes. If acceptable towfish navigation was logged, "CMG from SSSNavigation" should provide similar results. OCS does not recommend using heading data from the "sensor" field. This data is logged from the towfish's magnetic compass, which is subject to both magnetic variation and electrical interference.

If data were acquired using a Klein 5000 dynamically focused multibeam side scan sonar, the user must choose whether or not to convert hidden beams. There are five beams on each channel (port and starboard) of the Klein 5000. Based on range scale and towfish speed, the system will determine the number of beams necessary to achieve 100% coverage. Typical range scales and speeds used for hydrographic surveying require that 3 - 4 beams be used. Selecting “convert hidden” forces all 5 beams to be converted and may improve imagery in high yaw-rate conditions (e.g., in turns or for hull-mount configurations) or aid in detection of very small objects during activities such as search and recovery. However, for the purposes of a basic OCS hydrographic survey, converting hidden beams is not necessary to meet survey specifications and can introduce data management problems by significantly increasing file sizes.

The option to “Apply Image Enhancement” will automatically scale the side scan intensity values by a preset factor. This option could be considered a legacy item, as the user can now customize the contrast of side scan imagery using scale bars within the histogram window in Side Scan Editor. Applying Image Enhancement is unnecessary.

If the acquisition system was configured to log VBES data to an auxiliary (AUX) XTF datafield, the user can covert this data by checking the “Convert single beam from AUX field number” option and entering the field number used. Typically, this type of configuration should not be used because only one VBES frequency can be converted and OCS recommends converting and evaluating both high- and low-frequency VBES data, if possible.

Various side scan sonar systems may record imagery at different resolutions. Both Klein System 3000 and System 5000 imagery data are recorded at a resolution of 12 bits. When converting XTF files, choosing an 8-bit conversion will reduce the data resolution. Even though the recorded resolution is 12 bits, choosing the option to “Preserve 16-bit” will retain the original resolution.

4.3.3.1.4.2 Convert Layback/CableOut Data NOAA hydrographic field units typically record cable out during towed SSS acquisition to facilitate recomputing navigation, if necessary. The XTF format provides two datafields (“cableout” and “layback”) in which this information can be stored. The primary difference in these fields is that “cableout” will only accept integers, while a decimal number can be logged in the “layback” field. To preserve decimeter accuracy for cable out values, the field unit may use one of the two following options:

- Configure the vessel’s cable counter to output values in decimeters and log an integer value to the “cableout” field. However, SIPS assumes cable out data is in meters when recomputing. During conversion, the user can enter a “multiplier” of 0.1 to the “cableout” data that would reconvert the values to meters. For example, if acquiring SSS data with 10.6 meters of cable out, a cable counter integer output of 106 (decimeters) would be stored in the XTF “cableout” field. When converting the data in SIPS, the “cableout” value would be multiplied by 0.1 to recreate a value of 10.6 that SIPS assumes is in meters.
- Configure the acquisition system to log cable out, in meters and decimal meters, to the XTF “layback” field. In this scenario, the user must remember to convert data from the “layback” field, even though the data are actually values for cable out. SIPS will assume data from either datafield is cable out if towfish sensor depths are non-zero. (Similarly, if no towfish depths are converted, SIPS will interpret this as a zero sensor depth and assume data from either datafield are layback values.)

To determine towfish depth, both the Klein 3000 and Klein 5000 SSS systems calculate a value from an integrated pressure sensor. The Klein SSS device driver templates used with IsisSonar data acquisition software will automatically configure logging of towfish depth calculated from this pressure sensor data. If the hydrographer intends to use cable out to recompute navigation for a SSS system that does not have a pressure sensor, the towfish depth will need to be calculated based on water depth logged to an AUX field and towfish altitude. Typically, NOAA hydrographic field units will not need to calculate a sensor depth in this fashion.

Options	OCS Guidelines
Convert Side Scan - Sonar channels (1,2 or 3,4)	For single frequency systems, convert channels 1 and 2. When using multiple frequency systems, the user must determine which channel pair corresponds to the frequency they wish to convert.
- Navigation Datafield (ship or sensor)	Use navigation data stored in the “sensor” datafield to avoid potential timing problems.
- Gyro Datafield (ship, sensor, attitude packet, CMG from navigation, CMG from [sss] navigation)	Typically, use heading data from the “ship” datafield. If vessel crab angle is large, CMG may provide better imagery. Do not apply heading from the “sensor” datafield.
- Convert Hidden Data	Do not convert hidden beams as a standard practice.
- Apply image enhancement	Do not apply image enhancement as a standard practice.
- Convert single beam from AUX field num	Logging VBES data to an AUX field is not recommended. Thus, this option is not checked as a standard practice.
- 16 bit sonar conversion (preserve 16 bit, convert to 8 bit (scale or shift))	Choose to “Preserve 16-bit” resolution.
Convert Layback/CableOut data - From layback field - From cableout field (multiplier)	Convert cable out data from either field, depending upon the acquisition system configuration. If converting from the Cableout field, apply a multiplier to preserve decimeter accuracy.
- Calculate sensor depth using AUX field	This option is necessary only if recomputing navigation for a system that does not have a pressure sensor.

Table 4.12: OCS guidelines for converting XTF data.

4.3.3.2 Filter

SIPS does not provide filtering tools to automatically flag/reject “bad” imagery data. However, as when processing bathymetry, filtering can be performed on attitude and navigation data. Refer to 4.2.4.3.3 and 4.2.4.3.4 for details on Attitude Editor and Navigation Editor. Time-series data for gyro (heading), cable out, and sensor depth, as well as bottom tracking must be reviewed line-by-line and edited as necessary. If the SSS system is configured to calculate sensor depth based on sensor height and an auxiliary VBES depth, these sensors will also need to be reviewed.

4.3.3.3 Recompute Towfish Navigation

OCS typically uses one of two side scan sonar configurations, a towed sonar body or a hull-mounted sonar body. Regardless of system configuration, the hydrographer has the option of either computing the sensor position during data acquisition or recomputing towfish navigation during SIPS processing. If a towfish position is computed during acquisition and stored in the raw data format, this information can be converted directly into the SIPS towfish navigation data structure. If, in addition to ship navigation, either cable out and towfish depth or horizontal layback is recorded, the side scan sensor position can be calculated in SIPS via Recompute Towfish Navigation. OCS strongly recommends recomputing towfish navigation using cable out and towfish depth to determine towed sensor position. This process enables the hydrographer to review and edit, if necessary, the ship position data, cable counter data, and towfish depth or bottom tracking (if used to determine towfish depth) prior to calculating a towfish position.

Note: If horizontal layback or tow cable length data are not available or if the Recompute Towfish Navigation step is not executed, then the towfish navigation data recorded during acquisition will be used to georeference imagery. If, additionally, towfish navigation was not recorded during data acquisition, then the side scan sensor position data are assumed to be the same as the ship navigation data.

When using a hull-mounted configuration, navigation data for the sensor is typically determined by using ship navigation data and entering the vessel RP-to-towfish offset in the towpoint section of the HVF. However, SIPS will only apply the towpoint offset when navigation is recomputed. For this type of configuration, Recompute Towfish Navigation must be performed with a cable out value of zero.

Note: If no cable out data was converted, SIPS will assume cable out to be zero.

4.3.3.4 Slant Range Correction

Side scan sonar is initially logged as a series of time-indexed intensity values for each ping, i.e., the acrosstrack axis represents time. These data are considered “raw” side scan and are displayed with the central portion of the image representing the water column and a digital line along either the port or starboard leading edge indicating the logged bottom track. Some sonar systems will track bottom very accurately, while others require that these data be edited or redigitized. Any errors in bottom track should be edited prior to slant range correcting, as these data determine sonar height during the slant range correction process.

When data are slant range corrected, an estimate of the speed of sound through sea water is applied to the two-way travel time for each intensity value. This produces an estimated ray length that, when combined with the known sonar height (from the digitized or logged bottom), is used to produce the acrosstrack distance to a pixel using simple trigonometry. Slant range corrected data are displayed with the water column removed and the acrosstrack scale representing distance from nadir. It should be noted that this method presupposes that the bottom is flat across the ping and can result in the acrosstrack misplacement of objects over varied or steeply sloping terrain. If available, SIPS can use a BASE Surface, grid, or tile in the slant range correction operation to supply depth values and improve the acrosstrack positioning of pixels. This process is explained in detail in the CARIS HIPS and SIPS User’s Manual.

During the process of slant range correction, the resolution value will default to the minimum value appropriate for the sonar system. If this resolution is not feasible, it will default to 0.10 meters. Resolution may be manually increased, but keep in mind that increased resolution means a larger file size. The hydrographer will be required to make some arbitrary decisions regarding beam pattern correction and despeckling. The “Beam Pattern” function attempts to equalize the differences in pixel intensity from nadir to the outer ranges of the sonar swath. The “Despeckle” function detects isolated bright spots and streaks in the raw sonar file and smoothes them by averaging the neighboring pixels. Applying these options will produce a more attractive mosaic when creating constituent products, and should not hide small contacts during data processing. If SSS data were converted using the “Preserve 16-bit” option, the user can choose to “Create 8-Bit Processed Side Scan” to generate a slant range file requiring less storage space, if necessary. When slant-range correcting 16-bit data to create 8-bit side scan, a shift factor should be applied to spread out the histogram and improve imagery. The user can apply either the 16-bit shift factor stored with each line or a single bit shift factor to be applied to all lines. Generally, the bit shift factor stored with each line is a good choice.

4.3.3.5 Add to Mosaic

A survey-wide side scan mosaic should be created and maintained during Daily Batch Processing to evaluate data coverage, identify any gross systematic errors, and plan future data acquisition.

Note: If a 200% side scan survey is being conducted, a separate mosaic should be created to demonstrate coverage for each hundred percent.

In addition to planning future SSS acquisition, the first 100% mosaic can be used to delineate areas of high contact density where complete MBES coverage is more appropriate than 200% SSS. The hydrographer is reminded that AWOIS radii that extend beyond the basic survey limits must be entirely covered with 200% side scan, complete or object detection multibeam, or a combination thereof to be disproved by sonar data. These radii should be considered when evaluating survey coverage.

When creating a mosaic, the hydrographer will be prompted for several pieces of information. In accordance with section 6.2.1 of the HSSD, resolution shall be 1m by 1m or less. Maximum acrosstrack and altitude ratios can be used to systematically remove areas of poor quality data from the mosaic, such as when outer edges are affected by thermocline. Note: These features will not actually reject the imagery data, but they will remove portions indicated for all lines in the mosaic.

Options such as interpolation and shine-thru may be used at the hydrographer's discretion. These features may enhance the overall mosaic and can be desirable for creating constituent products.

4.3.4 Boat-day Processing

Boat-day Processing" as described in this chapter refers to that portion of the hydrographic data processing that is performed on a single vessel's data that were acquired during a single day of data acquisition. It is assumed that all the processes described in 4.3.3 of this chapter have already been performed. For ships and launches, this portion of the processing is typically accomplished during the "night processing" shift. For field parties, this processing step may be either saved for foul weather days or accomplished by a shore party member in charge of their unit's daily data processing.

The goal of imagery Boat-day Processing is to identify contacts that warrant further investigation and record these contacts in the digital data. This process is completed using SIPS Side Scan Editor.

4.3.4.1 Side Scan Editor

Imagery data should be reviewed twice using CARIS SIPS Side Scan Editor. The initial review process is referred to as "scanning" the data. The second review is performed by a different person and is called "check scanning." The initial reviewer should identify any object that warrants further investigation, often referred to as a "significant contact", and record these items into the digital data. The second review serves as a quality control, and should add any significant contacts that were overlooked during the initial check. SIPS provides several tools to assist in determining if a contact is significant. Two of the most frequently used are "Measure Shadow" and "Measure Distance."

"Measure Shadow" can be used to determine the height of an object by measuring its acoustic shadow and calculating the object's approximate elevation off the seafloor. This tool can only be used when viewing data in slant range corrected mode. "Measure Distance" is used to measure the distance between two points. This tool is helpful in determining the overall size of contacts, which may determine significance. For example, a very large item, even if it does not protrude significantly from the seafloor, may be listed in the AWOIS database and should therefore be investigated. The Measure Distance tool can be used when viewing both "raw" (i.e., not slant range corrected) and slant range corrected data.

All significant contacts should be recorded in the digital data by creating a contact in SIPS. (Refer to the CARIS HIPS and SIPS Users Guide for detailed information on how to create a contact.) The general OCS practice for determining significance of an imagery contact is stated in the HSSD.

The hydrographer must always consider the location of a contact when determining significance. For example, in a major channel where vessels transit with minimal underkeel clearance, a contact less than one meter high could be significant.

When a contact is recorded in SIPS, the item is geo-coded and attributes are attached to it in the Side Scan Editor. Each contact should be attributed as thoroughly as possible. A contact file is created for each survey line and is stored in the line folder within the Project directory structure.

4.3.5 Survey-wide Processing

"Survey-wide Processing" for imagery data consists of evaluating total coverage and assessing side scan contacts in NOAA's Pydro software to determine which items warrant further investigation or development, and attributing each contact accordingly in Pydro. Efficiency can be increased by conducting many of the survey-wide processing steps concurrently with Boat-day processing for global quality control and general survey completeness. These processes would include verifying adequate investigation of charted features and assigned AWOIS items within (or partially within) the survey sheet limits, reviewing the data for Dangers to Navigation (DTONs), and verifying that data coverage meets the assigned specifications. Reviewing these points on a daily basis will help to ensure a complete survey and a timely submission.

4.3.5.1 Reveiw Survey-wide Mosaic

Survey-wide mosaics are typically reviewed during Boat-day processing to assess coverage and insure that no significant data gaps, referred to as "holidays," are present in the imagery. Once 100% side scan coverage has been attained and demonstrated via the survey-wide mosaic, this "final mosaic" should be saved as a CARIS Fieldsheet and exported as a GeoTiff in UTM NAD 83 format. Both the Fieldsheet and GeoTiff image should be digitally filed for submission with the completed survey data. If the survey requires 200% side scan coverage, a separate final mosaic should be created for each hundred percent.

4.3.5.2 Assess Imagery Features

Throughout the survey process, imagery contacts should be periodically assessed and a determination made as to whether "development" is necessary. Developing an imagery contact typically refers to investigating the item with MBES to determine a least depth. However, other methods of obtaining a least depth may be used, such as VBES or DLDG. Some types of side scan sonar systems are able to acquire co-located imagery and bathymetry data. However, these systems are a developing technology, and SSS bathymetry has not yet been approved for OCS hydrographic surveys.

Imagery contacts should be assessed in Pydro, which enables the hydrographer to analyze each contact in context with other available data sources such as correlating contacts, the chart, bathymetry, DPs, and AWOIS records/search radii. Contacts should be evaluated and, if confirmed to be significant, flagged for “investigation” within Pydro. This flag enables the user to export that item to MapInfo MIF/MID and HYPACK TGT formats to plan for further investigation or development. (Once a contact has been exported, its Pydro record will indicate this via the “Tgt Exported” flag.) If correlating contacts or features exist, the image which best represents the contact should be flagged “Primary”, and all correlating contacts, AWOIS items, or charted features should be flagged “Secondary”.

Note: Any significant contact suspected to be a Danger to Navigation, as described in 4.4.4, shall be expedited through the investigation/development process and a DTON report submitted, if necessary.

Contacts which, upon further analysis, are determined not to be significant should be flagged “Resolved” and a note added to the Remarks tab of the Editor’s Notebook stating that the item is considered insignificant. Any contact which was erroneously inserted into the survey data, and can not be efficiently removed, should be flagged “Rejected” and an explanation entered in the Remarks tab. For additional information on analyzing and flagging contacts in Pydro, refer to 4.4.

The determination whether or not to develop an item from imagery data is considered a preliminary assessment of contacts. Once this decision has been made, significant contacts are considered imagery “features” and should be further processed as described in 4.4. This preliminary contact evaluation should not be confused with finalization of imagery data, where the goal is to verify that all contacts have been addressed and flagged either “resolved” or “rejected.”

4.3.5.3 Finalize Imagery Survey Data

Once all significant contacts have been developed, analyzed, and flagged in accordance with 4.4, the hydrographer should verify that no “Unresolved” imagery features remain in the Pydro PSS and a final mosaic, created in accordance with section 8.3.1 of the HSSD, has been generated and digitally filed for each 100% SSS data acquired.

4.4 Feature Processing and Analysis

In OCS surveys, a feature is an object that merits individual attention distinct from the bathymetric model of the sea floor.

In a general sense, the bathymetric model of the sea floor will be represented on the chart using soundings and contoured depth areas. Everything else: buoys, rocks, wrecks, piles, docks, etc. are features. During the acquisition of a hydrographic survey, the hydrographer will encounter many objects that may merit individual attention and treatment.

In some cases, this object will be of significant navigational interest and will eventually be portrayed as a distinct cartographic symbol on a chart. An example of this type of feature is a prominent wreck. Once discovered, the wreck will likely require further investigation. This may involve high resolution multibeam, side scan sonar, or diver investigation. This additional information is collected together and used to fully describe and categorize the wreck. Once processed, this information is passed to the Atlantic and Pacific Hydrographic branches and cartographers using formatted reports and digital data files. These data will aid the cartographer in correctly charting the feature.

In other cases, further investigation may indicate that the feature is not navigationally significant, and should not be charted as a distinct cartographic symbol. An example of this type of feature might be an object detected with side scan sonar that subsequent multibeam coverage found to be not of navigational concern (a patch of gravel perhaps). This feature would still be handled through the same methods as the wreck described above. This process serves as a record that the hydrographer properly inspected and handled all indications of an item of potential navigational significance.

In some other cases, the hydrographer may wish to call out an object for individual cartographic treatment even if the depth of the object is well represented in the bathymetric data set. For example, a large glacial erratic boulder on an otherwise flat and featureless sandy bottom may be of particular navigational significance, especially if there is a bottom trawl fishing fleet in the area. This object may be selected by the hydrographer and recommended for charting as an isolated feature rather than simply through soundings and contours.

We can see from these examples that the feature processing pipeline is used to: (1) gather together information on features that may eventually be added to the chart, (2) aid in assessing the feature's navigational significance, and (3) provide a mechanism for reporting this feature analysis to the Atlantic and Pacific Hydorgraphic branches.

Five basic sources of feature information must be analyzed and resolved when processing an OCS hydrographic survey: Bathymetry, side scan imagery, detached positions (DPs), AWOIS items, and geographic positions (GPs). The ability to resolve a feature depends heavily on viewing data in its full context. GIS (Geographic Information System) software can be used to spatially correlate a set of features both within the contemporary survey data and from other (prior) data sources, enabling the hydrographer to quickly identify redundant data on a single "real world" feature. Correlating information allows the hydrographer to confidently determine a feature's significance with respect to marine safety and nautical charting. The most important features that can be identified in a survey are those that pose a danger to navigation (DTON). Data should be reviewed daily to identify items that are DTONs, as described in 4.4.4. DTON processing shall be expedited to the greatest extent possible.

Non-DTON features should be evaluated and classified periodically as the survey progresses toward completion. Ultimately, all features should be evaluated, classified, developed (if necessary), and resolved.

NOAA hydrographic field units shall primarily use NOAA's Pydro software package or CARIS Notebook to analyze, organize, and document survey features. The capabilities of Pydro are described in further detail in 4.4.2. The capabilities of CARIS Notebook are described in further detail in 4.4.3.

4.4.1 Data Post-Processing

4.4.1.1 GPS Data Post-Processing

As described in 3.5.3, high accuracy GPS positioning frequently requires that the data acquired be post processed to apply all available corrections. This must be accomplished before the resulting feature positions are imported into the feature management environment for attribution and analysis. Most NOAA GPS post processing is accomplished by one of the following two methods.

4.4.1.1.1 OPUS GPS Processing The National Geodetic Survey's Online User Positioning Service (OPUS) is the most commonly used tool for post-processing dual frequency GPS data for positions requiring sub-meter accuracy. OPUS allows the surveyor to submit GPS data files in receiver-independent exchange (RINEX) format to NGS via the internet. The data are post-processed, using NGS's PAGES software, with respect to three Continuously Operating Reference Stations (CORS).. OPUS will try to select the three sites nearest to the user's location but will expand the search based on data availability and quality. Positions computed by OPUS are usually emailed to the user within a few minutes. Currently, OPUS can only process one position at a time, so multiple sessions must be submitted individually. A good solution will have an overall root mean square (RMS) value below 0.03m, using 90% of the observations, with over 50% of the ambiguities fixed.

Precise- ephemeris yield only marginally better results, and only for stations far from CORS. If time is an issue, rapid orbits are fine.

Additional information and specific instructions for OPUS processing are included in the CO-OPS Users Guide for GPS Observations (Appendix 3) and on the OPUS web page `http://geodesy.noaa.gov/OPUS/`.

4.4.1.1.2 Trimble Pathfinder Office Trimble Pathfinder Office includes a Differential Correction Utility which is used by many field units equipped with the Trimble ProXRS backpack GPS receiver. This utility makes use of the carrier phase data logged by the ProXRS and the NGS CORS network to produce positions of meter-level accuracy or better. Additional information and specific instructions for the Differential Correction Utility can be found in GPS Post Processing Methods document included in Appendix 4.

4.4.1.2 Target File Processing

. Several types of survey data, such as shoreline features, manually measured depths, and bottom samples, are positioned using target files. These files can not be read directly into CARIS; thus, Pydro has been developed to handle the bulk of target file processing. A HYPACK target file can be easily inserted into Pydro via Data > Insert > HYPACK DPs. Pydro's Data > Insert > Trimble/Pathfinder Database GPs+DPs imports a Microsoft Access database (.mdb) according to a specific, S-57 based Pathfinder data dictionary format developed in conjunction with NOAA Ship Fairweather. Separate tables are used in this Pathfinder database for separate S-57 object classes and geometry. For example, "OBSTRN_P", "OBSTRN_L", and "OBSTRN_A" tables may be present in a given database file for point-, line-, and area-geometry obstructions acquired in the field. And both GPs and DPs may be present in a given table; the "Tide – DP/GP" field is used by Pydro to segregate those observational types. Other "generic" target files can be read into Pydro via Data > Insert > Generic GPs/DPs, wherein users may configure a template for importing other data sources on a routine basis. Once inserted into Pydro the DP observational data can be edited, and the various attributes present in Pydro are added. Pydro automatically writes or "converts" (in the same sense of the term used by CARIS HIPS) DP datasets to CARIS HDCS data during data save operations. See 4.4.2 for more information.

Once a target file is written to the HDCS data, it can be opened in CARIS to continue processing DPs which correspond to depths. In CARIS, a tide file and, if necessary (i.e., for echosounder determined depths) a sound speed profile can be applied to DP data. The DPs must then be merged as per standard HIPS processing to create processed depths. If any subsequent edits to DP position or depth values are performed in Pydro and saved, the standard CARIS HIPS "outdated" status is active and data will need to be re-SV Corrected and re-merged in HIPS.

4.4.2 NOAA Pydro Software

NOAA's Pydro software package is used to bring the various source data for potential features, (side scan Sonar contacts, designated soundings, detached positions etc.) together in a geo-referenced interface. In most cases, Pydro maintains links to the source data which results in certain flags and edits applied in Pydro being automatically written into the source dataset, as noted in 4.4.6. Similarly, some types of editing performed in the raw data processing program (i.e., CARIS HIPS/SIPS) will be automatically carried through to Pydro.

Note: Some edits performed in CARIS, such as rejecting/accepting sounding data or imagery contacts, will require that the source data be re-inserted into Pydro.

Pydro has the ability to read several data types, including the following:

- Side scan imagery contacts created in CARIS SIPS.
- Bathymetry features in CARIS HIPS; i.e., soundings flagged "outstanding" and/or "designated".
- Bathymetry soundings in CARIS HIPS; shoal-biased binned line-by-line.
- Gridded bathymetry data created in CARIS HIPS; BASE surfaces (.hns) or weighted grids (.def/.sum/.weight) files.
- Target files from HYPACK (.tgt), Trimble Pathfinder (.mdb, etc.), and other generic data sources.
- The AWOIS database, in MS Access format.
- ENC (.000 files).
- Other "generic" geographic position data in many database formats, such as ESRI Shapefiles (.shp), MapInfo Interchange Files (MIF/MID), MS Excel, dBase (.dbf), ASCII, etc.
- ENC S-57 base cells (.000) rendered according to S-52 and various raster formats for background data, including GeoTIFF (.tif), MrSID (.sdf), and NOAA/BSB raster nautical charts (.kap)

Once these data are imported into Pydro for a specific survey, the combined data package is referred to as a Pydro Survey Session (PSS).

Note: The Pydro PSS is not to be confused with the historical "preliminary smooth sheet", which was a plotted presentation of survey data formerly required for submission.

Within the PSS, items can be marked with digital notes, various flags, and attributes to aid in decision making and reporting. Items are automatically correlated according to a user-specified radius or can be manually re-correlated and grouped to form sets of observations that represent the same physical item. The best data for reporting a feature, e.g., the most accurate least depth observation from the available bathymetry and/or most descriptive picture from the available imagery, is designated via a defined flagging schema. Pydro also includes a number of automated reporting functions, such as reports for DTONs, charted features, new features, and AWOIS, as well as Requests for Tides. By generating these reports directly from the digital data, error prone "cut and paste" actions can be avoided and report formats are easily standardized. In general, standardizing feature processing and maintaining a digital record of all field observations and recommendations for features helps maintain quality control throughout the hydrographic data pipeline.

4.4.3 CARIS Notebook Software

CARIS Notebook is used to bring together various data types, including features, images and bathymetry into a georeferenced user interface. CARIS Notebook is very effective at managing line and area features such as reefs, foul areas, piers etc, and is NOAA's primary software for managing features in surveys that contain shoreline verification.

Notebook has the ability to read several data types, including the following:

- ENCs, or other S-57 databases (.hob, .000)
- Raster displays: (.kap, .tif)
- Vector files (.shp, .dxf, .des)
- Gridded CARIS Surfaces (.hns, .hcs)
- Pydro XML files
- CARIS Mosaics
- CARIS Contours
- CARIS Sounding Plots

Once these data are imported into Notebook for a specific survey, they are saved into a Notebook session, which can be opened as a cohesive unit.

Within each Notebook Session, there can be numerous types of information to assist in processing and analyzing potential features. Charts, georeferenced images, CARIS HIPS and SIPS generated data products etc. assist in feature analysis while the features themselves are housed in non-standard 000 files called HOB files. Each feature within a HOB file is fully S-57 attributed with specially created (non S-52 compliant) data entry fields for the hydrographer to enter remarks and recommendations. The hydrographer also has the ability to insert marker tags to provide additional information about a feature or area of a survey. S-57 attributed features processed and analyzed in Pydro can be inserted directly into CARIS Notebook. Features and their associated markers are submitted in three well defined HOB files: Original Composite Source HOB, Final Features HOB, and Disprovals HOB. Additional information on these files is documented in 4.4.10.

4.4.4 Dangers to Navigation (DToNs)

The most important features to identify in a survey are Dangers to Navigation (DTON). A DTON is defined as any uncharted or incorrectly charted natural feature (e.g., shoal, boulder, reef, rock outcropping) or cultural feature (e.g., wreck, obstruction, pile, wellhead) that poses an immediate threat to surface navigation. General chart discrepancies can be addressed at the conclusion of a survey, but items that meet DTON criteria should be reported as soon as practicable after discovery.

The primary characteristic of a DTON is navigational significance. When reviewing survey data for potential DTONs, the hydrographer must consider the types of vessels operating in the area as well as vessel routes, both typical and seasonal. Much of the final selection of DTONs is subjective and requires a bit of cartographic interpretation as well as a navigational perspective of the chart. Examination of newly acquired survey data for potential DTONs should be performed on a daily basis.

The following guidelines can be used to identify potential DTONs; however, each item should be further evaluated for significance within that specific geographical area.

4.4.4.1 Water Depth

Historically, selection of DTONs has been concentrated in areas with water depths of 20 meters or less. While this remains a good rule of thumb, this depth range should be evaluated in the context of vessel traffic and typical routes through the area. For example, features in water deeper than 20 meters may be DTONs along routes for supertankers.

4.4.4.2 Potential DTON Height

Typically, survey features and soundings indicating a depth discrepancy of 1 meter or greater are first evaluated for DTON potential. Again, this guideline should not be followed blindly. Vessel traffic must be considered. If vessels transit the area with minimal underkeel clearance, a discrepancy of only 1/3 meter could be critical; or, if a deep inland bay or harbor is accessible only by shoaler restricted channels, a large feature within the deep water area may not be a hazard since only small vessels could access the area. Figure 4.17 illustrates a potential DTON located within a channel. If the channel's tabulated depth is listed as 40 feet for the right outside quarter, then this charting discrepancy would only be 1 foot. Typically, a 1-foot discrepancy would not be considered a DTON. However, the hydrographer must consider what type of vessels transit the area and how much water they draw. This channel might be the entrance to a major port facility where vessels drawing 40 feet arrive on the rising tide. In such a case, this 1-foot difference is critical, particularly if the item is a rock or cultural feature as opposed to a sandy shoal.

Figure 4.18 shows a small bay with depth discrepancies of 2 fathoms (12 feet). Although this depth difference is significant, the bay is accessible only by passing through a 5 or 6 fathom channel. Thus, the 7 fathom sounding inside the bay is insignificant, i.e., not a DTON. Similarly, a very large object identified in a river accessible only by small craft may not be a DTON. Figure 4.19 shows a potential DTON located in a deep section of a small river. The object in question protrudes over 10 meters from the seafloor. However, this river happens to be accessible only by small craft, due to a shoal at its mouth. Despite this large depth discrepancy, the item is navigationally insignificant when the hydrographer considers the draft of vessels capable of operating in the area.

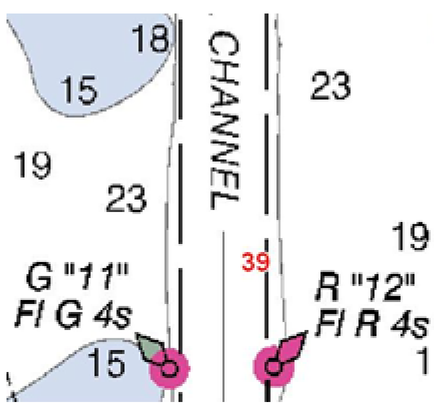

Figure 4.17: Potential DToN located in a channel.

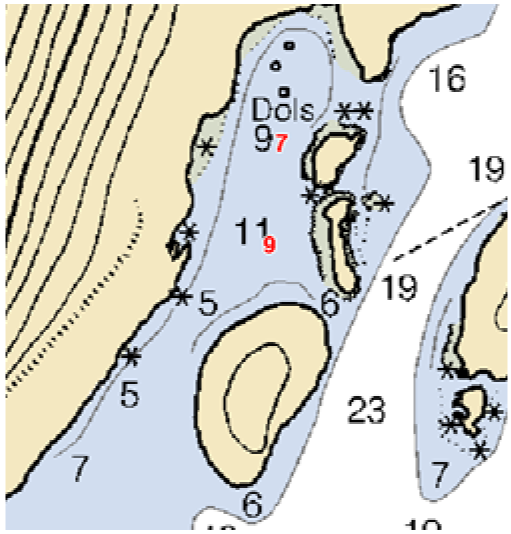

Figure 4.18: Potential DToN in a small bay with restricted access.

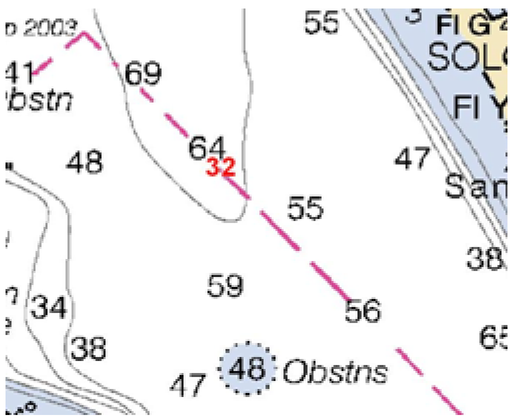

Figure 4.19: Potential DToN located in a deep section of a small river.

4.4.4.3 Proximity to Existing Features

Many new or uncharted features are potential DTONs. The hydrographer must consider each new item's proximity to existing features (rocks, reefs, fish havens, shoreline, foul areas, etc.) and the item's significance with respect to these adjacent features. Figure 4.20 illustrates a case where an existing feature (Fish Haven with an authorized minimum of 15 feet) affects the significance of a potential DTON. In this example, an item intended for the fish haven may have been erroneously deposited outside the haven's geographical bounds, a very realistic scenario. Despite the discrepancy with regard to the charted 43 foot depth, the adjacent Fish Haven to the south/southwest and shoal to the east would deter prudent mariners from approaching the area. Likewise, a large depth discrepancy adjacent to a reef or foul area would quite possibly not be a DTON, again, as a prudent mariner would operate in the area only with extreme caution.

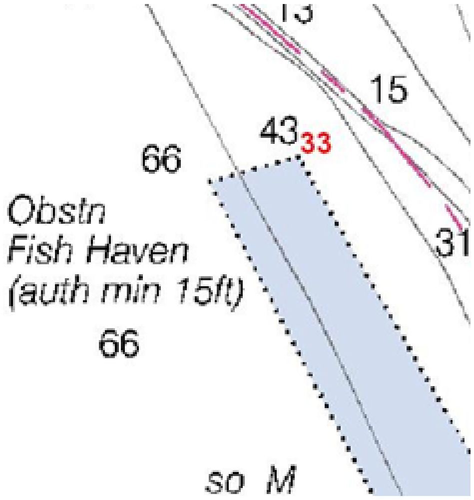

Figure 4.20: Potential DToN adjacent to a charted fish haven.

4.4.4.4 Dense Groups of DToNs

The density of DTONs reported should not exceed what can be legibly portrayed on the largest scale chart of the area. If numerous DTON candidates are identified in close proximity, the hydrographer could report either the most significant item or the group of DTONs as an area feature, e.g., designate the entire area "foul." When determining the most significant DTON in a group, the item having the shoalest least depth will typically be chosen. However, this may not be the case if, for example, the item is located on a slope. Typically, if two potential DTON are adjacent on a slope, the most seaward sounding will be selected for submission. The prudent mariner will assume that depths will decrease as shore is approached. An example of this exception is shown in 4.21 . The 2 fathom sounding is shoaler, but the 4 fathom sounding extends further offshore. In this case, the 4 fathom sounding would be submitted. Although both soundings would supersede the 5¾ fathom charted depth, it can be reasonably inferred that there is a continuous slope toward shore, therefore depths shoaler than 4 fathoms would be expected.

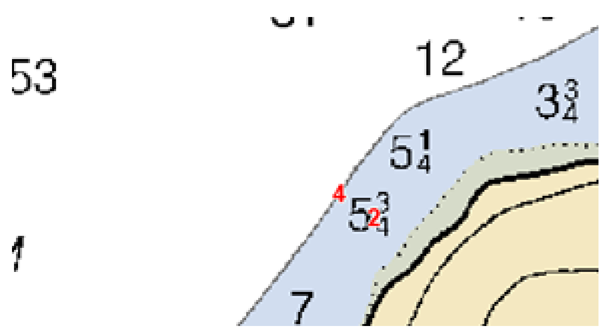

Figure 4.21: Two potential DToNs located in close proximity on a slope.

4.4.4.5 Charted Feature Removal Request

A Charted Feature Removal Request, often referred to as an "anti-DTON," is used to expeditiously remove charted features that are hindering operations in major shipping corridors and have been adequately disproved. Only navigationally critical items should be submitted as Charted Feature Removal Requests. These requests should be submitted using the same procedure indicated for DTONs in this manual. The hydrographer should include any Charted Feature Removal Requests with the Danger to Navigation reports in Appendix I of the Descriptive Report for the applicable survey.

4.4.4.6 DToN Submission (see section 8.1.2 of HSSD)

Typically, DTON selections should be reviewed by the Chief-of-Party prior to submission. If approved, DTONs must be flagged properly in Pydro (see 4.4.6.1.3), which can then generate a DTON report. Note: All Pydro PSS Metadata should be completed prior to generating a DTON report so that this information will be included in the report. The Pydro DTON report is generated in a Zip archive which contains an Adobe *.pdf text report, an *.xml file containing the survey data for that feature, and a DTONImages folder containing all the relevant chartlets (always included) and report images (user selectable). The Zip archive should be submitted to NOAA's Marine Chart Division (MCD) via email (ocs.ndb@noaa.gov), with courtesy copies to the Chief of OPS and to the Chief of the appropriate hydrographic branch.

For the DTON report, field units may use either Pydro or HydroMI to generate a charlet. If the charlet is generated externally to Pydro, users must add those charlets to the *.pdf report manually. Note: The Pydro report includes a zip file of the *.pdf so field units must make sure the report to MCD is updated before submittal if the HydroMI chartlet is going to be used.

Additional actions, as noted below, are required when reporting DTONs in the following two cases.

1. If the potential DTON will directly impact commercial shipping routes and/or is located within an area of Army Corps of Engineers' authority, the appropriate NOAA Navigation Manager shall be consulted prior to submitting the DTON.

2. If a DTON report includes a potentially historically-significant wreck, the field unit shall provide a courtesy copy of the report sections pertaining to that specific feature to the corresponding NOAA Navigation Manager and State Historic Preservation Officer. If a potentially historically-significant wreck is identified outside of state waters, notify the current Sanctuaries Historical/Archaeological contact.

Once submitted, all DTONs will be expedited through MCD to the Coast Guard for publication in the Local Notice to Mariners. Within three days of DTON report submission, MCD's Nautical Data Branch (NDB) will send an email to the field unit confirming that DTON data has been received and processed. If a DTON submission is not confirmed by NDB within one week, the hydrographer should promptly contact MCD (via an inquiry email to ocs.ndb@noaa.gov) to verify that the report has been received and processed.

4.4.5 Cultural or Historical Submerged Features

In the course of acquiring or processing hydrographic data, features on the seafloor may be discovered which are of potential cultural or historical significance. These include wrecks of ships or aircraft, the recognizable debris from wrecks, or other items which may appear anthropogenic in origin and have some associated cultural or historical significance.

Chiefs-of-Party must always promptly assess the discovery of any features for significance to local surface navigation and report these accordingly. Any feature determined to be a Danger to Navigation shall be immediately reported through the standard DTON reporting process (see Section 4.4.4).

It is Marine Chart Division (MCD) policy that all features recommended for charting by the Chief-of-Party be applied to the appropriate nautical charts. Chiefs-of-Party must continue to recommend for charting all features determined to be significant to surface navigation, as well as features determined to be significant or hazardous to other marine chart users engaged in activities such as fishing or trawling. This includes features which may have potential cultural or historical significance. This policy is unchanged and in accordance with the MCD Nautical Charting Manual.

All features which appear to be of cultural or historical significance, and appear anthropogenic in origin, do require special consideration during the hydrographic surveying process. Data and information from these features must always be protected and may only be released in accordance with OCS policies and procedures. Unless specified by the Project Instructions (or other written instructions from OCS):

1. Do not attempt to determine the cultural or historic significance of any features. And, do not expend any operational effort toward identification beyond what is necessary for assessment as a Danger to Navigation.
2. Do not speculate about a known or newly discovered feature's potential cultural or historical significance, either publicly or in writing.
3. Do not identify by name or otherwise associate with a name, any cultural or historical feature in the Descriptive Report (DR) or any part of the survey's data.
4. *DO* include an image, SSS or bathymetry, of the feature in the Pydro feature report for recognition by a historian or preservation official.

OCS, as a unit of a federal agency, has responsibilities under Section 106 of the National Historic Preservation Act (NHPA, 16 U.S.C. 470 et seq.) to take into account the effects of its undertakings on historic properties. The process for federal agencies in complying with the NHPA is laid out in 36 C.F.R. Part 800, which prescribes consultation with the State Historic Preservation Officer (SHPO).

1. OCS will consult with the NOAA National Marine Sanctuaries Program (NMSP) Marine Historian where hydrographic projects are located within Federal waters, including National Marine Sanctuary boundaries.
2. OCS will also consult with the appropriate SHPO where hydrographic projects are located in state waters.

OCS consultations for hydrographic projects provide information about planned survey activities, and about survey outcomes. A pre- or post-survey consult will allow NMSP or a SHPO at least 30 days to respond.

In general, NOAA field units are not required to submit any data to NMSP or a SHPO. All consultations will be conducted by OCS.

4.4.5.1 Pre-survey Consult

A pre-survey consult will be initiated during the project planning process by OCS HSD Operations Branch (or NSD Navigation Response Branch). Any responses or special handling that may be required of a NOAA field unit will be provided in the Project Instructions.

A pre-survey consult with NMSP or a SHPO may be anticipated to result in one of three general outcomes:

1. **No Response** – HSD Operations branch will note this and the project instructions will not require any special data handling.

2. **Informational response** – Information about known or reported features of cultural or historical significance may be received by OCS following the pre-survey consult period. An informational response means information from NMSP or a SHPO received by OCS is provided without any restriction for public release. This information will be included with the Project Instructions. The project instructions will not require any special data handling.

3. **Actionable response** – Specific information received following the NMSP or SHPO pre-survey consult period may prevent the public release of all or part of the survey data or products. The specific information received following a pre-survey consult period will be evaluated by OCS HSD Operations Branch, and clear instructions for data handling will be provided.

4.4.5.2 Post-survey Consult

A post-survey consult will be initiated by HSD's Atlantic Hydrographic Branch (AHB) or Pacific Hydrographic Branch (PHB). Immediately upon receiving a data submission, AHB or PHB will provide a copy of survey's composite Descriptive Report (DR) that includes the written DR, the feature report, and the Danger to Navigation report to the NMSP and/or SHPO specified in the Project Instructions, and request a direct response within 30 days.AHB or PHB will provide courtesy copies of the DR Transmittal Letter to:

1. Chief, HSD or NSD

2. Chief, HSD Operations Branch or NSD Navigation Response Branch

3. Regional Navigation Manager (as assigned in the Project Instructions)

The composite DR may be transmitted by e-mail or on letterhead, with a message in the following form:

The National Oceanic and Atmospheric Administration's Office of Coast Survey (OCS) previously contacted you regarding hydrographic surveys in [location] on or about [dates]. A Descriptive Report for one of those surveys is attached for your information. Please provide any comments regarding this survey within 30 days with reference to survey [insert registry number] to [insert name] Chief, [Atlantic or Pacific] Hydrographic Branch [insert telephone, e-mail, and mailing address]. If we have not received a response in 30 days, we will assume that the survey data may be made publicly available.

A post-survey consult with NMSP or a SHPO may be anticipated to result in one of three general outcomes:

1. **No Response** – All survey data and products will be made publically available through NGDC following an affirmative Survey Acceptance and Review (SAR) by the either the Atlantic or Pacific Hydrographic Branch.

2. **Informational response** – An informational response means information from NMSP or a SHPO received by OCS is provided without any restriction for public release. If received following a post-survey consult, this information will be inserted into the survey's DR as supplemental correspondence. All survey data and products will be made publically available through NGDC following an affirmative SAR by the assigned OCS HSD Hydrographic Branch.

3. **Actionable response** – Specific information received following a post-survey consult will be evaluated by the assigned OCS HSD Hydrographic Branch. This evaluation may result in all or some of the survey data and products to be not made publically available through NGDC following an affirmative Survey Acceptance and Review (SAR) by the assigned OCS HSD Hydrographic Branch.

The policies and procedures described in this section should never cause a delay in the completion of a hydrographic survey and the immediate notification of potential Dangers to Navigation. Any questions regarding cultural or historical submerged features should be promptly directed to the Chief, HSD Operations Branch.

4.4.6 Pydro Feature Classification

Source data that correlates with features in a NOAA hydrographic survey are typically classified in one of the following five categories in Pydro:

- Items from Bathymetry – Sounding data (MBES or VBES) which has been identified as a measurement of a least depth on a feature in CARIS HIPS or Pydro. ”Designated” soundings can also be selected to force the gridded surface to honor the true depth of the seafloor.
- Items from Imagery – A potentially significant feature which has been identified in SSS data, chosen as a contact in CARIS SIPS during post-processing, and to be evaluated for further investigation and/or development.
- Detached Positions (DP) – Detached positions are used to position point features such as shoreline items, bottom sample locations, DLDG depth determinations, and lead line or pole soundings. DPs are subdivided into echosounder and non-echosounder types. Echosounder DPs are used for data with a corresponding depth determined by VBES, MBES, or another system which is referenced to a point other than the water’s surface and require the application of vessel offsets. Non-echosounder DPs are used to provide positions for data either with no associated depth information or referenced to the water’s surface, such as DLDG determined depths and heights of shoreline features.
- AWOIS Items – AWOIS items represent features which have been previously reported or surveyed and are generally included on the current chart. Specific AWOIS items within, or partially within, each survey area will be assigned for investigation.
- Geographic Positions (GP) – Geographic positions refer to point data used for various purposes and not otherwise classified. These points are typically uploaded from a portable GPS system, manually digitized in Pydro, or created by inserting ”generic” data into Pydro. Two sub-types of GPs exist in Pydro: “Chart GPs” and “Checkpoints”. The principal use of Chart GPs in Pydro is to indicate those survey items which represent new observations on existing charted features, or otherwise disprovals thereof (see 4.4.6.1 and subsections, including 4.4.6.1.20). Checkpoints provide for a way to steer some comparison of survey data at discrete locations.. As each feature is evaluated in Pydro, standard classification flags should be set. A Pydro data flagging decision tree is provided in Figure 4.22 to assist the hydrographer with this process. The basic process involves systematically reviewing survey data for features, by segregating correlating groups of items into a best-representative “Primary” item + supporting “Secondary” item(s). This decision process involves examining survey items in context with all supporting data available: any previously known items (AWOIS and other currently-charted features) and bathymetry (current survey, prior survey, charted soundings, etc.). Note: An item from bathymetry representing the least depth of a navigationally significant real-world feature should always be marked Primary.

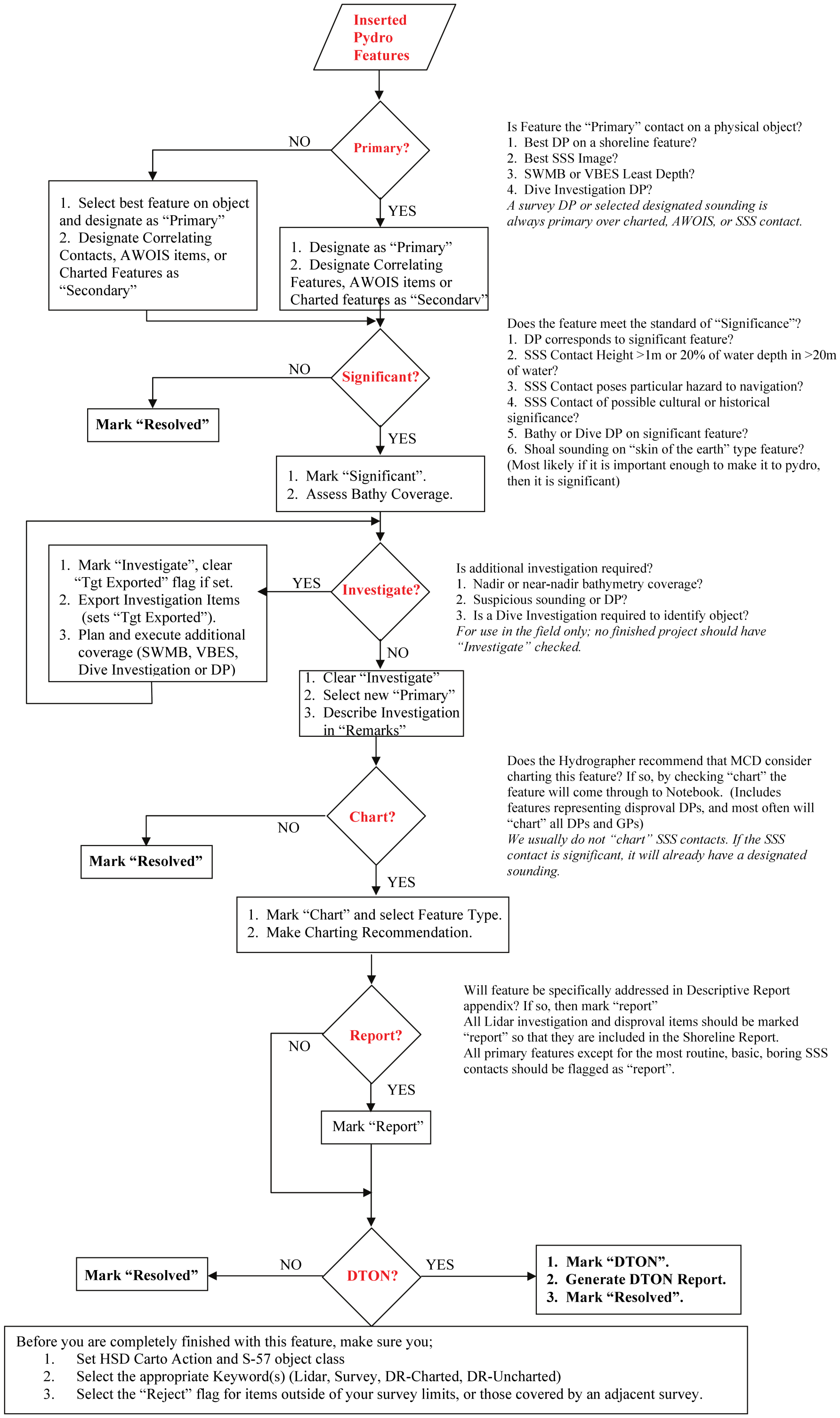

Figure 4.22: Pydro data flagging decision tree.

For all the correlating items that represent the same feature as the Primary item, set the status flag to Secondary. If an item has been automatically correlated to a Primary item, but does not appear to be the same feature, assign it as Primary. That is, use the Primary item status to segregate features. If your survey makes use of side scan sonar, this means you will often encounter disparate features through items from imagery before having supporting item(s) from bathymetry. Go ahead and set the status flag to Primary for such items, knowing that if they prove to be navigationally significant, a bathy item will take precedence as the Primary item when available. If there are items that represent a common feature that have not been automatically correlated by distance, use Pydro's Group Features tool to manually associate those items. Certain subsequent flagging actions to be made towards a feature need only be carried out on the Primary item because they are propagated through to the flags of all Secondary items, as noted in 4.4.6.1. Each feature should be reviewed to determine if it is significant based on either the NOAA contact height criteria set forth in 4.4.4. of this manual or some other criteria determined by the field unit. Other criteria include, but are not limited to, proximity to a maintained channel, predominant ship/boat traffic in the area, proximity to other significant features etc. If so, check the "Significant" flag. If the feature requires additional data acquisition to be resolved, also check the "Investigate" flag. The purpose of the Investigate flag is to remind the field hydrographer that more information, possibly involving additional data acquisition, is necessary to adequately resolve the least depth or nature of a feature. All items marked "Investigate" may be exported to both MapInfo Interchange Format files (MIF/MID) and Hypack Target files (.tgt) to facilitate additional data acquisition; the "Tgt Exported" flag is set upon item export. Add any additional information not otherwise explicit in the Primary item's digital data to the Remarks tab in the Editor's Notebook. If the feature is not Significant and does not require further investigation, check the "Resolved" flag and state why it has been Resolved without further investigation in the Remarks tab. An example of such a case would be if the contact represents a charted buoy block.

When significant features have been adequately investigated, the hydrographer should thoroughly attribute each item according to the S-57 standard and evaluate whether it should be included on the H-cell and charted. If the hydrographer believes a feature should be charted, the Chart flag should be checked and, if known, the specific cartographic action that is required should be selected: "Chart-Add", "Chart-Modify", or "Chart-Delete" ("Chart-?" for unknown cartographic action) . Any specific charting recommendations not otherwise explicit in the digital data itself can be included under the "Recommendations" tab in the Editor Notebook (i.e., do not cut-and-paste survey position, least depth, etc. into the descriptive text). Charting recommendations are not necessary for every feature, but may be used to further clarify complex items, as discussed in 4.4.6.2. If a feature needs to be explicitly discussed in the Descriptive Report (e.g., it requires the addition and/or removal of a cartographic symbol, not simply updating charted depths) the "Report" flag should also be checked. The "Report" flag indicates that Pydro should include the item in a "For Descriptive Report" feature report to be submitted as Appendix II of the Descriptive Report. This is a process that often warrants the input and judgement of an experienced hydrographer. If in doubt, please ask the advice of the Field Operations Officer, NRT Team Lead, Commanding Officer or senior Processing Branch Personnel.

4.4.6.1 Standardized Flag Definitions

4.4.6.1.1 Pending, Primary or Secondary In Pydro, "status" is used to associate PSS items that correlate to a given real world feature, or lack thereof in the case of disproving the existence of a charted feature. Status defaults to Pending for all items inserted or otherwise created in Pydro. Relative status levels can be assigned for sets of spatially correlated or grouped items. One PSS item identifying a given real world feature should be assigned Primary status and the remainder of the items associated with this feature should be assigned Secondary status. Since all significant imagery features should be investigated using bathymetric methods, the final Primary item should be either based on bathymetry data or a DP, unless the item is insignificant or significance could not otherwise be determined before the termination of data acquisition. No Pending items shall remain in the Pydro PSS file for a completed survey submitted to AHB or PHB.

4.4.6.1.2 Chart This flag designates items regarded by the hydrographer as representing a real feature and warrants inclusion on the H-cell and subsequent nautical charting products. If applied to a Primary feature, the Chart flag will automatically be applied to all correlating Secondary features.

4.4.6.1.3 DToN This flag designates items regarded by the hydrographer as representing a real feature that poses a danger to navigation; items can be marked as DToN only if they are first flagged Chart. If applied to a Primary feature, the DToN flag will automatically be applied to all correlating Secondary features.

4.4.6.1.4 Submitted This flag denotes that items flagged as Primary+Chart+DToN have been exported from Pydro to a DTON report for submission to MCD. Once marked Submitted, these items will not be re-exported during creation of subsequent DTON reports unless the "Submitted" flag is manually cleared prior to generating the report.

4.4.6.1.5 Report This flag designates items to be included in the Pydro-generated "For Descriptive Report" feature report. This feature report shall be submitted as Appendix II of the Descriptive Report.

4.4.6.1.6 Resolved This flag indicates that field examination and analysis have been completed for an item. If applied to a Primary feature, the Resolved flag will automatically be applied to all correlating Secondary features. The Pydro PSS for a completed survey to be submitted to AHB or PHB shall not contain any Unresolved items.

4.4.6.1.7 Office QC This flag denotes that AHB/PHB examination and verification have been completed for an item. The Pydro PSS for a completed survey to be submitted to HSD or otherwise archived shall not contain any Primary items that are not flagged Office QC. This is a Processing Branch tool only.

4.4.6.1.8 Rejected This flag identifies any item that the hydrographer does not want included in the survey. Any pertinent information explaining why the feature has been rejected should be included under the Remarks tab of the Editor's Notebook.

Rejecting an imagery feature in Pydro will flag the corresponding SIPS contact as rejected, but will not delete the contact. Rejecting a bathymetry feature in Pydro will clear the Outstanding flag in HIPS, but will not reject the corresponding sounding data.

4.4.6.1.9 Significant This flag is used to identify features which meet the NOAA significant contact height criteria set forth in the HSSD (see section 5.1.2 and 6.2.1), or some other priority condition determined by the field unit, and warrant further investigation and/or development. If applied to a Primary feature, the Significant flag will automatically be applied to all correlating Secondary features.

4.4.6.1.10 Investigate This flag enables the direct export of specific items to MapInfo MIF/MID and HYPACK TGT format for planning further investigation or development. This flag is a field management tool only and should not be checked in a submitted survey.

4.4.6.1.11 Tgt Exported This flag denotes that an item was flagged Investigate and has been exported to MapInfo MIF/MID and HYPACK TGT format, typically for some subsequent investigation procedure. This flag will be set automatically when “Export Investigation Items” function in Pydro is performed. Once marked Tgt Exported, these items will not be re-exported unless the Tgt Exported flag is manually cleared prior to performing the export.

4.4.6.1.12 In Bathy This flag is used to force a feature’s least depth to be explicitly included in the PSS database of shoal-biased binned line (PVDL) data for plotting in Pydro, MapInfo (via Hydro_MI’s “Draw PSS” function), or otherwise exported from Pydro. A sounding must first be classified as a bathymetric feature to be designated In Bathy. Once flagged In Bathy, that depth will take priority over other PVDL bathymetry data and other feature depths in the PSS during over-plot removal.

4.4.6.1.13 Designated This flag is used to force a feature’s least depth to be explicitly included in the two PSS bathymetry databases (as applicable) for display/analysis in Pydro (both over-plot removed Depths and ZSurfaces), plotting in MapInfo (via Hydro_MI’s “Draw Pydro Data” Post Survey tool), or otherwise exported from Pydro: (i) HIPS BASE/Weighted Grid data and (ii) shoal-biased binned line (PVDL) data. During bathymetry layer over-plot removal (aka “excessing”) in Pydro, feature depths may suppress other (deeper) feature depths; however, non-feature depths do not suppress feature depths, regardless of magnitude (i.e., all feature depths are regarded as being shoaler than all other depth nodes in the grid). In CARIS, the Designated flag should be used when a single least depth measurement is preferred over the weighted-mean depth calculation for BASE surface grid nodes. Designated soundings often equate to navigational significance and, hence, the desire for a symbolized feature to be rendered on the chart—and why HIPS Designated soundings are read into Pydro as candidate features (items from bathymetry). However, this is not always the case. For example, if the area of least depth has been adequately surveyed, yet contains a small number of soundings, the Designated flag should be used. Also, if a feature’s least depth was determined by DLDG, the Designated flagging mechanism must be used to accurately represent the (single) measurement in the BASE surface. Designated soundings are applied to the BASE surface during the Finalize step in CARIS by checking the "Apply designated soundings" option.

4.4.6.1.14 Outstanding Literally flagging a sounding Outstanding can only be accomplished in HIPS, but this action correlates to creating a bathymetry feature in Pydro. In other words, a sounding flagged Outstanding in the HDCS data will automatically be a bathymetry feature in the PSS. Likewise, creating a bathymetry feature in Pydro will write an Outstanding flag back to that sounding in the HDCS data.

4.4.6.1.15 Keyword Users can expand the set of flags used for items in a PSS by making Keyword assignments to features under the Keyword tab in the Editor’s Notebook. A Keyword can be any arbitrary length string. Once a new Keyword is added to the PSS, it is available to assign to other features. Standard Keyword values pre-defined in Pydro include “DR_Charted” and “DR_UnCharted,” as described in 4.4.9.1.

The following subsections describe the most common flagging combinations for survey items, grouped by data acquisition type: items from bathymetry (HIPS processed depths flagged

Outstanding and/or Designated), imagery (SIPS contacts), DPs, AWOIS, and other geographical positions (GPs). Note that emphasis is given on Primary-flagged items, rather than including a multitude of possibilities for Secondary items. Flagging scenarios for Secondary features are included only when needed to further explain the related Primary item.

4.4.6.1.16 Items from Bathymetry

4.4.6.1.16.1 Primary, Resolved This flag combination indicates any bathymetry feature that is not addressed in the DR (note the absence of the Report flag). Any secondary items to this Primary should add further credence to the decision not to include this item in the DR; other information and reasoning should be detailed in the item's Remarks tab. This item may consist of a bathymetric feature later determined to be insignificant. This flag combination should be used for all designated soundings that were selected to force the uncertainty surface to honor the true sea floor—but not otherwise elevated to the level of desire for an explicit feature symbology on the chart.

4.4.6.1.16.2 Primary, Chart, Resolved This flag combination indicates any bathymetry feature that is included as an explicit feature on the PSS, but not specifically addressed in the DR (note the absence of the Report flag). This flag combination is uncommon, but sometimes used when depicting complex shoreline with a series of DPs. Further information and reasoning should be detailed in the item's Remarks tab. This item may or may not be associated with a Secondary imagery item, DP, GP, or AWOIS item.

4.4.6.1.16.3 Primary, Chart, Report, Resolved This flag combination indicates any bathymetry feature that is included as an explicit feature on the PSS and is specifically addressed in the DR. Further information and reasoning should be detailed in the item's Remarks tab. This item may or may not be associated with a Secondary imagery item, DP, GP, or AWOIS item.

4.4.6.1.16.4 Primary, Chart, DToN, Report, Submitted, Resolved This flag combination indicates any bathymetry feature that is included as an explicit feature on the PSS, is specifically addressed in the DR, and has been submitted to MCD as a DTON. Further information and reasoning should be detailed in the item's Remarks tab. This item may or may not be associated with a Secondary imagery item, DP, GP, or AWOIS item.

4.4.6.1.17 Items from Imagery

4.4.6.1.17.1 Primary, Resolved This flag combination indicates any insignificant contact that was not developed (otherwise imagery item should be Secondary to a bathymetry-based feature). Further information and reasoning should be detailed in the item's Remarks tab. This flag combination often indicates a contact that, after further evaluation, was determined to be insignificant.

4.4.6.1.17.2 Primary, Tgt Exported, Resolved This flag combination denotes a contact that was exported, presumably for subsequent investigation, and found to be insignificant (otherwise imagery item would be Secondary to a bathymetry-based item). The item is not addressed in DR. Further information and reasoning should be detailed in the item's Remarks tab.

4.4.6.1.17.3 Primary, Chart, Report, Resolved This flag combination indicates any imagery item that was determined to be a significant contact, but was not investigated. The item is addressed in the DR. Further information and reasoning should be detailed in the item's Remarks tab. Imagery items should typically not be flagged Primary+Chart since they do not provide an accurate depth for charting. Except in extenuating circumstances, significant items from imagery should always be Secondary to a (Primary) bathymetry-based item. An example of when this flagging scenario could be used is when the field unit acquired SSS imagery, but left the area before a significant contact could be developed with bathymetry or diver investigation. This scenario is not common, but is sometimes unavoidable.

4.4.6.1.18 Detached Positions (DPs)

4.4.6.1.18.1 Primary, Rejected, Resolved This flag combination indicates any detached positions that the hydrographer does not want to be part of the survey. Further information and reasoning as to why it was rejected, such as because it was a blunder or a DP on an unassigned AWOIS item, should be added in the feature's Remarks tab.

4.4.6.1.18.2 Primary, Resolved This flag combination indicates any detached positions included for informational purposes only, which are not addressed in the DR. Further information and reasoning should be detailed in the item's Remarks tab.

4.4.6.1.18.3 Primary, Chart, Resolved This flag combination indicates any detached positions that are depicted on the PSS as features but not addressed specifically in the DR. Some examples of when this flagging scenario might be used are as follows: (i) recording bottom sample locations, (ii) positioning shoreline features, and (iii) verifying positions of aids to navigation.

4.4.6.1.18.4 Primary, Chart, Report, Resolved This flag combination indicates any detached positions that are depicted on the PSS as features and are addressed specifically in the DR. Some examples of when this flagging scenario might be used are as follows: (i) least depths determined by DLDG that either do not have supporting echosounder bathymetry or any correlating echosounder bathymetry is flagged Secondary, and (ii) portraying complex shoreline, including issues such as changes to MHW and shoreline feature disprovals.

4.4.6.1.19 AWOIS Items

4.4.6.1.19.1 Primary, Resolved This flag combination indicates an AWOIS item that was disproved using one of the investigation methods assigned in the database record. See 4.4.9.1. It can also be used to indicate an AWOIS item that does not fall directly into a survey area, but whose search radius partially falls within the survey area, and has been or will be addressed by an adjoining survey. Further information should be added to the item's Remarks tab.

4.4.6.1.19.2 Secondary—to [Primary] Bathymetry Item or DP This flag combination indicates any AWOIS item that was located/verified during the survey. See 4.4.9.1.

4.4.6.1.20 Geographic Positions (GPs) GPs are any point data that do not fit into another feature category. As Secondary items, they can be used to convey information that is outside the scope of standard features in Pydro. GPs may be either inserted into Pydro from some “generic” ASCII or database format or manually digitized via the context menu in a Pydro Chart Window. GPs can optionally be assigned under the sub-categories “ChartGPs” and “Checkpoints”. An explicit function exists in Pydro to insert S-57 ENC features as ChartGPs into the PSS for evaluation of survey items in context with the (official) chart.

Secondary ChartGPs are used to indicate the connection of the associated Primary item to an existing charted feature. Such a relationship instructs Pydro’s DR document builder to file a Primary+Report feature under the “Charted Features” chapter; absence of a Secondary ChartGP (and no Secondary AWOIS) directs a Primary+Report feature to the “New Features” chapter. For details, see 4.4.9.1.

Checkpoint GPs can be created in Pydro if survey features do not exist at desired comparison locations for (say) a Pydro Points/Surface Stats Report. Refer to 5.2.3.3.2.

GPs can be created as placeholders for the information necessary to disprove a feature, without the need for an item to be explicitly logged during data acquisition. Photographs and other details about the techniques used to disprove a feature (e.g., search radius and method) are important pieces of information to include with such a disproval GP.

4.4.6.1.21 Pydro Flagging for export to Notebook Features that will be added to the Field Verified HOB: All features that are flagged as “Primary” + “Chart - ?” (carto action = “none”), and have been S-57 attributed, shall be brought into Notebook via an XML Features File export from Pydro. This exported feature selection is achieved via the feature template filter mechanism in Pydro, to select the subset of features out of the PSS with the aforementioned flagging combination. An interim Pydro_Updates.HOB will be created from the XML, which will later be copied into the Field Verified HOB in the final deliverable

Features that will be added to the Disprovals HOB: All features that are flagged as “Primary” + “Chart - Delete” (carto action = “delete”), and have been S-57 attributed as a cartosymbol, will be brought into Notebook as the Pydro_Delete.HOB. As described above, this too is based on the feature template filter mechanism in Pydro. Once the survey is complete, these features will then copied into the Disprovals HOB in the final deliverable S-57 Attribution: Double Check that all features that you wish to have exported to Notebook have the correct S-57 attribution in the S-57 Editor Window. Features without an S-57 attribution will not be exported from Caris Notebook.

4.4.6.2 S-57 Attribution

S 57 is shorthand for the International Hydrographic Organization (IHO) Special Publication No. 57, “IHO Transfer Standard for Digital Hydrographic Data.” An S-57 file is a database of feature object classes and associated attribute types. Multiple object class “instances” are often required to describe a single real-world feature. For example, a lighted lateral buoy with a horn is described with three object classes in S-57: BOYLAT (buoy, lateral), LIGHTS (lights), and FOGSIG (fog signal). Attribute types under each object class are used to indicate the specific makeup of the feature; e.g., COLOUR (colors), COLPAT (color pattern; applicable if dealing with more than one color), CATFOG (category of fog signal), etc. As demonstrated in this example, all S-57 object classes and attribute types utilize a 6-letter acronym naming convention.

Feature object classes that have meaningful geometry contain a spatial component in the S-57 data, where point, line, and area geometry is possible. The IHO ENC Product Specification details what S-57 objects and related attributes and geometry are permissible for official, for-navigation charts produced by hydrographic offices around the world, like NOAA. Example 1 : An S-57 rock is encoded using object class UWTROC, and has (say) a attribute type WATLEV = “always dry” Example 2: A bottom sample is classified using object class SBDARE and can be given attributes such as COLOUR, NATSUR (nature of surface) and NATQUA (nature of surface – qualifying terms), These attributes could be filled in with (say) brown, sticky, and mud respectively.

S-57 feature designation and attribution is assigned for user-selected items in Pydro via an S-57 Editor dialog. As noted in section 4.4.6, certain subsequent flagging actions to be made towards a feature—in this case, S-57 markup, need only be carried out on the Primary item because they are propagated through to the flags of all Secondary items. Select an object in the ”Object Classes” list by checking the box adjacent to the desired object class description. The corresponding 6-digit acronym for any highlighted class name in the list is shown in the mouse pointer tooltip while hovering over the “Object Classes” button; and, clicking on the button opens up a help file detailing the meaning of the object class. The mandatory and additional attributes per the ENC Product Specification are shown on separate notebook pages in the Pydro S-57 Editor. All mandatory attributes must be filled out. Certain attributes do not require manual editing; instead, the attribute is linked to the digital data present in the Pydro XML feature data (manual editing for such attributes is in fact disabled). For example, if the S-57 attribute VALSOU (value of sounding) is associated with the feature, the Pydro XML <depth> element value will automatically appear in the depth editing box. Fill out the other boxes on the Additional Attributes notebook page in the S-57 Editor dialog according to your field observation.

Source Date and Source Indication (SORDAT and SORIND) are mandatory attributes that have a standard data entry format. The standard source date is the last day of your survey, encoded in the format CCYYMMDD (4 digits for calendar year – CCYY, 2 digits for the month – MM, and 2 digits for the day of the month – DD; e.g., 19820506 = 6 May 1983); the standard source indication for new or modified features identified by your survey is formatted according to the template US,US,survey,HXXXX. The 6-digit acronym for a particular S-57 attribute is shown in the mouse pointer tooltip while hovering over any attribute button in the Pydro S-57 Editor; and click on an attribute button to open a help file for more information. S-57 feature attribution is required for all Pydro XML Primary items that represent a real-world feature recommendation for inclusion on the official navigational chart. Edit the S 57 object/attribute instances to describe each real world feature as completely as possible. Again, multiple object classes and their associated set of attributes may apply to a given feature.

For further guidance on S-57 attribution, use the Field Encoding Guide in the chapter 3 appendix and the LIDAR deliverables logic docuement in the chapter 4 appendix.

4.4.6.3 Feature Remarks and Recommendations

The “Remarks” and “Recommendations” text fields in Pydro’s Editor Notebooks are used to provide survey data reviewers and cartographers additional information about features. The hydrographer’s feature remarks should include techniques used to identify the feature, what the feature is and additional information that is not be captured elsewhere in the digital data (e.g., flags, S-57 attribution, keywords, etc.). Remarks shall be written either in longhand or using the standard abbreviations tabulated in this chapter’s appendices. Only the primary item representing the feature in Pydro requires a remark, but the remark may often contain information about the secondary items as well.

Example scenario regarding remarks: A least depth on a wreck (say) was selected to be the primary feature in Pydro. The contacts selected from imagery and an associated AWOIS item are secondary to that sounding. The remarks section of the primary feature should reference the supporting data from imagery contacts and the AWOIS item. An example of a remark for this feature is: "Sounding is least depth on obstruction. Obstruction was identified using 200% SSS, and least depth determined using Reson 8125. Feature is determined to be AWOIS item #5546."

Do NOT copy-and-paste digital data that is already included as part of the Pydro report. Exact geographic positions (Latitude and Longitude), least depths, etc. are already part of the document, and re-writing these values in the remarks only adds opportunity for error; changed values from reprocessing, not to mention human blunders, will necessitate unnecessary and time-consuming quality assurance checks during data review. One slight exception to this rule is the practice of including the correlating AWOIS number (RECRD field) in the hydrographer's remarks. Although Pydro's PDF report output will automatically show a heading of "Primary Item for AWOIS #<RECRD>" (based on the existence of a Secondary AWOIS item in the survey feature correlation), an explicit reference made by the hydrographer in the Primary item's "Remarks" has been deemed necessary.

It is the hydrographer's responsibility to analyze the current survey's features and examine them in relation to their position and importance on the chart. In conducting this comparison, recommendations as to whether a feature should appear using distinct symbology on the chart is requested. While explicit charting recommendations are not mandatory, and are considered unnecessary for typical features which have been thoroughly attributed according to the IHO's S-57 standard (i.e., the digital data "speaks" for itself), it is important to clearly communicate all information necessary to ensure proper charting of a feature. For those features that require further clarification, specific charting notes, etc., should be inserted under the "Recommendations" tab in the Pydro Editor Notebook so that they will be included in the "For Descriptive Report" feature report to be submitted as Appendix II of the DR.

An example scenario which warrants charting recommendations on a feature is when unconventional search methods are used, or when the search methods did not meet specifications, but which the hydrographer feels are adequate to justify the removal of a feature from the chart (feature disprovals). In this case the Hydrographer must describe the search methods, any data reviewed, and supporting information that would lead a prudent reviewer to the same conclusion. This information would reside in the remarks field in the Pydro editor window. The Hydrographer would then recommend removing the charted item in the Recommendations field. An example of a feature that would not require a charting recommendation is a bathymetry feature attributed in S-57 as a wreck. Such a feature would clearly be charted as a wreck, with the least depth indicated by the feature's bathymetry record and automatically linked to the feature's S-57 attribute VALSOU (value of sounding) by Pydro. If in doubt about the need to make a recommendation, err on the side of caution by making a recommendation.

4.4.7 CARIS Notebook Feature Management

4.4.7.1 HOB file management

Surveys that contain traditional shoreline verification are required to compile and submit their features and feature disprovals in CARIS Notebook HOB files. All of the source features (those currently on the chart and from previous surveys) are compiled at HSD OPS and are provided to the field unit for verification as a 000 file on the Project CD. This file is converted to a HOB file, clipped to the size of the survey and is retained without edits as the Original_Composite_Source HOB. A copy of the Original_Composite_Source HOB is created and renamed Final Features HOB. In addition, a disprovals HOB is created as a home for all items to be removed from the chart. All updates and changes to the original source shoreline will be managed and delivered in the Final Features and Disprovals HOB files.

4.4.7.2 New and Modified Features in Notebook

One of Notebook's strengths is its ability to create and edit line and area features. New features are added as S-57 attributed objects through the feature editing function in Notebook. The hydrographer is required to input mandatory S-57 attributes before he or she can begin digitizing the new feature. The shape and extents of existing features, such as MLLW, ledges, foul areas etc, can also be modified using the same function. All additions and modifications require a remark in the remarks field and an updated source date (SORDAT) and source indication (SORIND). All new and modified features are submitted in the Final Features File.

Line objects or point objects defining extents may be delivered for all area features. While area objects of ledges, reefs and foul areas are not required, in the case of kelp or eel grass areas, or any other S-57 area objects for which "line" is not an option, the preferred method may be to generate an area.

4.4.7.3 Use of SORDAT & SORIND

Disproved features will always maintain the original SORDAT and SORIND. For features other than Disprovals, the SORDAT and SORIND attribute fields must be populated for all features added or altered in any way, including a simple addition of a note in the Remarks field. For these features SORDAT and SORIND are modified to reflect the survey end date and survey registry number. This will call the attention of the branch cartographer to the feature. Instances which require altering SORDAT and SORIND are as follows:

- New feature
- Modification to the geographic position of a feature
- Modification to the geometry (shape) of a feature
- Modification to the geographic primitive of a feature (example: point becomes line)
- Modification to a feature's object class
- Modification or addition to a feature's attribution
- Addition of a note to Remarks or other field

4.4.7.4 Use of Remarks and Recommendations Attribute Fields

Populate the Notebook feature Remarks field for all Disprovals and for every feature contained in the deliverables that includes the new SORDAT and SORIND. The same information that was recommended to be included in the Pydro Remarks field is also recommended for Notebook Remarks. Features in the Field_Verified HOB that maintain their original SORDAT and SORIND should not have any changes made to any attribute field, including Remarks. In these cases use a Marker to convey additional information.

Recommendations are required for all charted feature Disprovals, but not otherwise required for any Field_Verified features if Remarks suffice.

Through documentation and attribution it should be clear what action the branch cartographer is to take: add to chart, delete from chart, chart rock as ledge as digitized, etc.

4.4.8 Feature Investigation

Significant items identified during mainscheme hydrography should be further investigated to obtain an accurate least depth for each. For charted features such as AWOIS items, further investigation may be necessary to disprove an item's existence. These investigation processes are commonly referred to as "developing" a feature. The preferred method of development is full MBES coverage. If multiple MBES systems are available, the highest frequency sonar system effective in the item's depth of water should be used to obtain the highest resolution data. If MBES development is not feasible, VBES development and/or a diver investigation may be substituted.

4.4.8.1 MBES Development

Typically, a significant feature's approximate position and height will have been determined, either from SSS or MBES mainscheme data. Since MBES data are most accurate in the nadir region of the swath, a multibeam development should include a survey line that passes directly over the feature. Data density should meet the criteria for Object Detection Multibeam coverage as defined in section 5.1.2 of the HSSD. Depending upon the size of the item, subsequent lines can be added to either side of the original line until full coverage is achieved. It is recommended that an additional line be run orthogonally over the feature's anticipated least depth. It is common for marine life to gather around large features, often creating noise in MBES data. This additional line provides both an alternate perspective and additional data to identify noise and support a final least depth determination. See 2.5.3.4 for information on planning developments.

4.4.8.2 VBES Development

If a field unit does not have MBES capability, VBES can be used to determine a feature's least depth. If possible, side scan sonar should first be used to determine the feature's approximate position and height. Side scan images from different aspects may assist the hydrographer with feature identification. Carefully review the imagery for possible slender, vertical protrusions (e.g., masts, spars, outriggers, spuds, piles, etc.), and measure approximate heights above the seafloor for any protrusions observed.

Perform a full VBES investigation, using both high- and low-frequencies if available. If the item is large, start with two parallel survey lines over the feature. Continue running lines, parallel to the first two, until the least depth is detected. Decrease line spacing as necessary. If the feature is narrow, such as a pile, start with a single line over the contact position, working to each side at 5 meter line spacing until the object is found. An adequate investigation will exist when high frequency echosounder coverage has been accomplished for a minimum of three sounding lines, crossing the full extent of the feature, and the center line is shoaler than the outside lines. If vertical protrusions were suspected and not detected, additional sounding lines should be run at further-reduced line spacing until the echosounder detects the vertical protrusion or the hydrographer is confident that the suspected protrusion does not exist.

Successful completion of the requirements listed in the above steps constitutes an adequate VBES investigation. The shoalest depth recorded during the examination should be accepted as the least depth. Note: an exact match of heights above the seafloor determined by echosounder and side scan sonar shadow length will most likely not occur. The side scan contact shadow height is approximate and will be portrayed and measured differently when the contact is located in the near range region, as opposed to the far range regions of the swath.

If the hydrographer determines that the VBES cannot detect a vertical protrusion identified in the side scan records and using divers is not a feasible option, document the item with the most accurate least depth that the field has acquired and recommend that additional field work be performed.

4.4.8.3 Diver Investigation

If a feature can not be adequately identified and resolved using acoustic methods, a diver investigation may be necessary. When conducting any dive operations, you must comply with NOAA Administrative Order 209-123, commonly referred to as “NOAA diving regulations” (see Appendix 4 and the latest edition of the NOAA Diving Manual. Prior to conducting the dive, any nearby AWOIS records should be reviewed so that the items may be correlated using visual confirmation. Divers should conduct a visual inspection and determine a least depth using a Diver’s Least Depth Gauge (DLDG.) Refer to 3.2.5 for details on use of the DLDG. Once the least depth has been identified, divers should place a buoy at this point so that the support vessel can obtain a DP for the feature’s least depth. If additional bottom time is available, it is often useful for the diver’s to record details of the feature via a sketch with dimensions, azimuth of the item.

Note: Before leaving the dive area, a CTD sound speed profile must be acquired, as this will be necessary for processing the DLDG pressure data.

Soon after completion of the dive, the dive team should complete a final sketch of the item with the least depth position identified and any additional details recorded.

4.4.9 Feature Reporting (Pydro)

Investigation procedures and results for significant features must be documented and flagged in Pydro so that they will be included in the “For Descriptive Report” feature report to be submitted as Appendix II of the DR. Feature descriptions should be recorded under the Remarks tab of the Editor’s Notebook. After bathymetry data from developments and/or DLDG pressures have been processed, each investigated feature should be associated with a least depth.

The hydrographer should review each significant unresolved feature and associated bathymetry data. The shoalest valid sounding for each item is the least depth and should be designated a bathymetry feature in Pydro. Make the status of bathymetry features indicating least depths Primary, as they provide both depth and, in all likelihood, a better horizontal position than the original contact. Unless the original contact was used to determine the feature’s least depth, set the status of the original contact as Secondary to the new bathymetry feature.

If the feature is determined to be a DTON, a charted item, an uncharted (new) item, or an AWOIS item, the Primary record should be appropriately flagged in Pydro for inclusion in the “For Descriptive Report” feature report. Typical flagging combinations for these items are described in 4.4.6.1. Any specific charting recommendations should be entered under the Recommendations tab of the Editor’s Notebook. Guidance for making charting recommendations is included in 4.4.6.2. If the item does not require further investigation or additional reporting (i.e., it is not a new DTON) flag the feature as Resolved.

All feature reports should be generated with Survey Position in degrees-minutes-seconds format unless an alternate format is specifically required due to unusual operational circumstances.

Note that a LIDAR deliverables decison logic document can be found in the chapter 4 appendix.

4.4.9.1 Flagging for Automated Feature Reports

The following sets of mutually-exclusive flag logic are used by Pydro to categorize all survey features into separate chapters within the “For Descriptive Report” PDF output to be submitted as Appendix II of the DR. The separate chapters in this report include: “Dangers to Navigation”, “Charted Features”, “New Features” (currently uncharted, to-be-charted), and “AWOIS Features”. Each chapter corresponds to a physical Pydro *.treetemplate file used to filter and categorize items for the feature report. These standardized DR feature tree templates may be loaded in the Pydro application to review the content of the chapters within the context of a GIS. Refer to flag definitions and flagging scenarios in 4.4.6.1 for additional clarification on the individual flags used in each logic grouping.

4.4.9.1.1 DR_DToN This flagging is used to segregate survey features addressed as “DTONs” in the DR. Only one logic path (a) can be used to denote an item as DR_DToN: (a) Primary + Accepted [i.e., not flagged Rejected] + Chart + DToN

4.4.9.1.2 DR_Charted This flagging is used to segregate survey features addressed as “charted items” in the DR. Two logic paths (a,b) can be used to denote an item as DR_Charted:

(a) Report + Primary + Accepted + Non-DTONs [i.e., not flagged DToN] + Secondary ChartGP, but no Secondary from AWOIS. (b) Report + [Keyword==“DR_Charted”], but may not meet the criteria in (a).

4.4.9.1.3 DR_UnCharted This flagging is used to segregate survey features addressed as “uncharted (new) items” in the DR. Two logic paths (a,b) can be used to denote an item as DR_UnCharted: (a) Report + Primary + Accepted + Non-DTONs, with no Secondary from Chart GP or AWOIS. (b) Report + [Keyword==“DR_UnCharted”], but may not meet the criteria in (a).

4.4.9.1.4 DR_AWOIS This flagging is used to segregate survey features addressed as “AWOIS items” in the DR. Two logic paths (a,b) can be used to denote an item as DR_AWOIS: (a) Report + Primary + Accepted + Non-DTONs + Secondary AWOIS (b) Report + Primary AWOIS

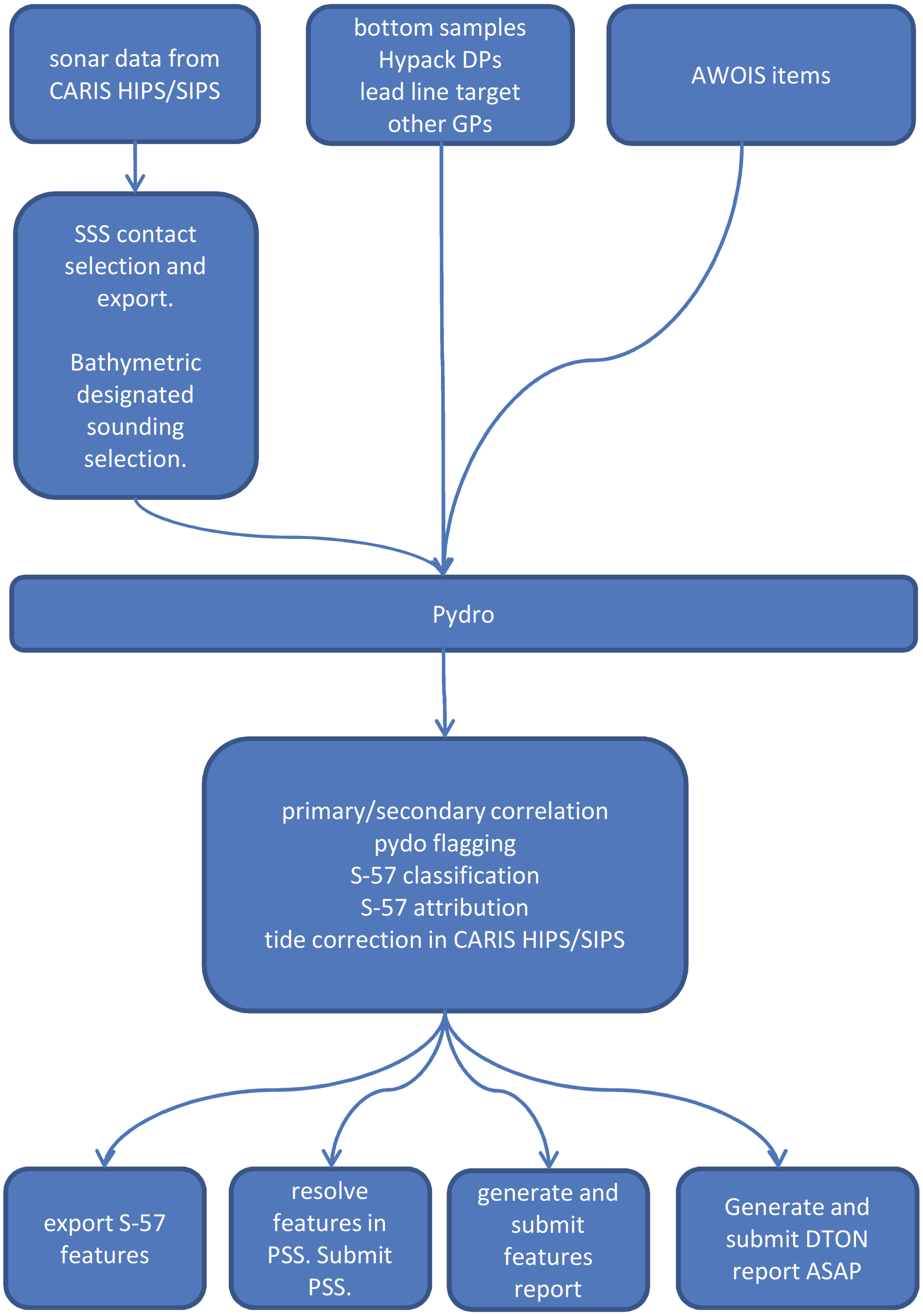

Figure 4.23: Feature Processing Flow Diagram (Pydro)

4.4.10 Feature Reporting (Notebook)

4.4.10.1 Required Files

The following are the three HOB files that are required for Notebook Feature submission. The elements of each layer are described in brief below followed by specific examples in the next section:

1. Original Composite Source: HXXXXX_Original_Comp_Source.hob. The original composite HOB contains the features from the Composite source clipped to the limits of the survey sheet. This file remains unaltered through delivery to the processing branch.

2. Final Features: HXXXXX_Final_Features_File.hob. The Final Features layer contains the Original_Composite_Source HOB with survey updates. Features contained in the Final_Features HOB include:

   (a) new features

   (b) modification due to: attribution, geometry, feature object class, or position

   (c) Features from multiple sources (i.e. deconfliction), including all assigned LIDAR investigation items and LIDAR features that have been verified or modified (see the LIDAR deliverables logic document in the chapter 4 appendix). Retain best represented feature. Move remaining features to the Disprovals layer.

   (d) Features Not Addressed, including all assigned LIDAR investigation items that could not be verified,remain in the Final Features layer. This includes features inshore of the NALL and features from multiple sources which cannot be deconflicted.

   Placement into or retention of an item in Final_Features is not an implicit agreement that it should be compiled to the chart.

3. Disprovals: HXXXXX_Disprovals.hob. Features from Composite Source that have been disproved, including all LIDAR investigation items that have been disproved, should be moved from Field_Verified to Disprovals. Examples include situations where:

   (a) Feature no longer exists

   (b) Geographic position is altered

   (c) Geographic primitive is altered (i.e. point feature modified to a line; point modified to an area, etc.)

4. Photos: Photos should be submitted in a folder named HXXXXX_Photos along with the three Notebook features files listed above. Any naming format for individual photos is acceptable as long as it includes a unique identifying number that can be referenced in the feature's Remarks attribute field and in the Descriptive Report.

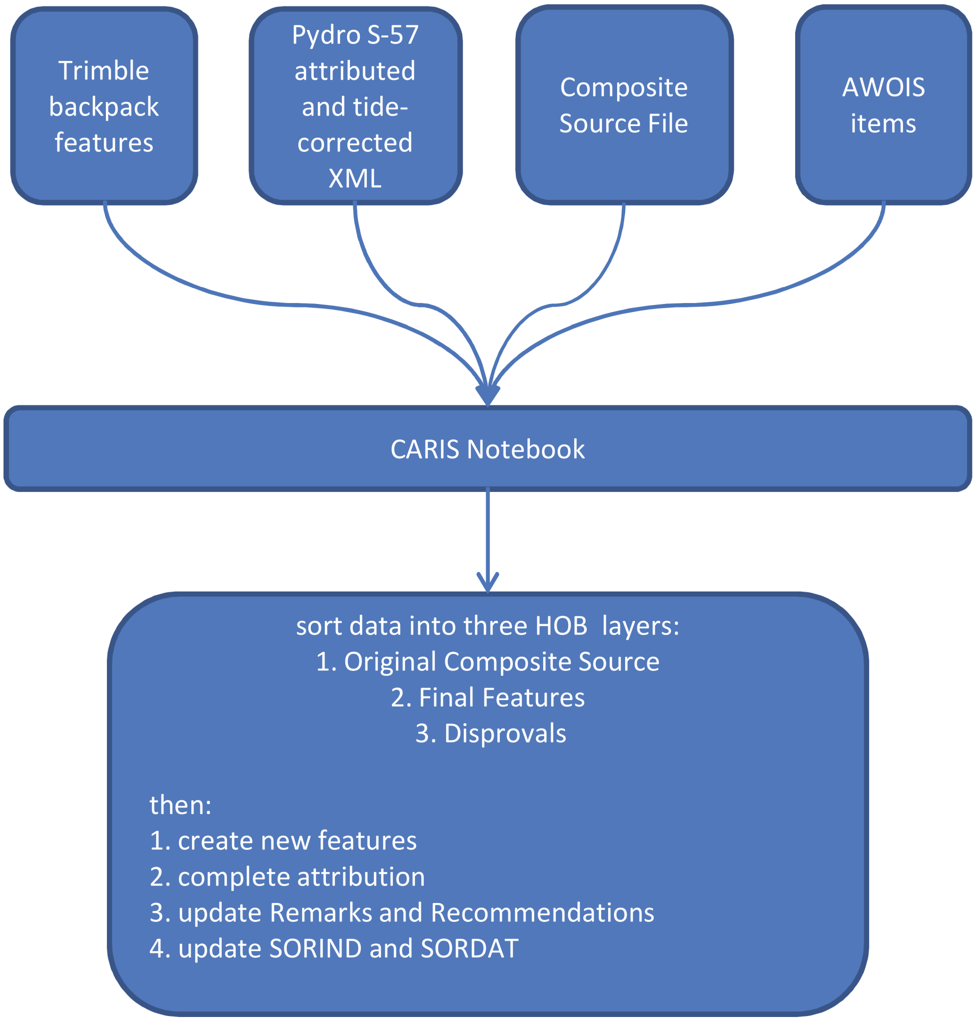

Figure 4.24: Feature Processing Flow Diagram (CARIS Notebook)

4.4.10.2 Examples of Features

Final Features: HXXXXX_Final_Features_File.hob

The final Final_Features retains all Original_Composite_Source features that were addressed but that were not edited in any way. These features maintain the original SORDAT and SORIND. No attribution, such as Remarks or Recommendations, should be added. This will alert the processing branch to retain the feature for charting. Any additional information needed should be conveyed using Markers.

- Example 1: A GC rock is determined to correctly portray the feature investigated during shoreline verification. No attribution, such as height, is added. This would formerly have been indicated using “GC rock OK” or GC rock noted”.

- Example 2: For LIDAR features that are verified (it has been verified that the feature exists as portrayed), but that you would not recommend charting as a feature, treat these as any other verified feature, retaining it as is in the Final_Features layer. A Remark or Recommendation may be used, at the hydrographer’s discretion, to convey information to the cartographer.

Final_Features includes all new features.

- Example: A charted rock is found to be the high point of a new reef. The rock is attributed with height (VALSOU), as measured in the field and tide corrected. It is assigned the new SORDAT and SORIND, and a Remark, and is retained on the Final_Features layer. A SBDARE line (NATSUR = Rock) is digitized to Final_Features using the observed reef extents as a guide, assigned the new SORDAT and SORIND, and given a Remark. The processing branch will create an area object of the SBDARE line.

Final_Features includes features where only attribution is changed for any object.

- Example 1: A height measurement is taken for a GC rock. The rock is retained in the Final_Features layer, VALSOU field populated, and the feature assigned the new SORDAT and SORIND. A Remark is included to note the addition of the height attribution. (Note: As long as Final Approved Water Levels are applied to the survey prior to transmittal from the field unit to HSD, “DPs for Height” are retained in the Pydro PSS, but not included in any .hob file deliverable.)
- Example 2 : The color of a mooring buoy is found to be orange rather than the yellow shown on the chart. The COLOUR attribute is changed for the MORFAC feature, and the feature assigned the new SORDAT and SORIND. A Remark is included to note the change of the color attribution.
- Example 3 : A section of charted MLLW line is determined to be the seaward most extent of a ledge. The affected section of MLLW (DEPCNT) line is changed to SBDARE line, NATSUR, Rock, on the Final_Features layer. The SBDARE line is attributed with the new SORDAT and SORIND. The change of feature object is noted in Remarks.

Final_Features includes features that reflect a change of feature object from one object class to another, without change to geographic primitive.

- Example: A charted pile is found to be a dolphin. The PILPNT designation is changed to MORFAC, dolphin, and the new SORIND and SORDAT are assigned to the new feature. The feature object change is noted in Remarks.

Final_Features includes features that were repositioned. The original mis-positioned feature is moved to Disprovals, maintaining the original SORDAT and SORIND, and given an appropriate Remark. The repositioned feature on Final_Features is assigned the new SORDAT and SORIND and will have a Remark stating that it was repositioned.

- Example: A charted obstruction is found to be charted 500 meters south of its true position. The incorrectly positioned OBSTRN feature is moved to Disprovals, retaining its original SORDAT and SORIND. The feature includes a Remark, and because it is a charted feature disproval, a Recommendation is also added. A new correctly positioned OBSTRN is added to Final_Features. It is assigned the current survey’s registry number and date for SORIND and SORDAT as well as a Remark.

Final_Features includes features that reflect a change in geometric primitive (from point to area, or area to point). The feature with the new geometry is in the Final Features HOB while the feature with the old geometry is moved to the disprovals layer.

- Example: A charted reef is found to be correctly positioned, but is determined to be a small islet rather than a reef. A LNDARE point object is used to depict the islet, and height given using a LNDELV object. New SORDAT and SORIND and a Remark are assigned the

LNDARE and LNDELV objects and they are placed on the Final_Features layer. The original reef is moved to Disprovals, maintaining all its original attribution including SORDAT and SORIND. Because it is a charted feature disproval both a Remark and a Recommendation are added to the feature.

Where features from multiple sources are given in the composite source for deconfliction, the feature that is selected as the best representation is retained in Final_Features, maintaining its original SORDAT and SORIND. A remark stating why the feature was selected to be retained and what methods were used to make this determination is included in a Marker Note. The remaining features are moved to the Disprovals layer. Each disproved feature retains its original SORDAT and SORIND and is given a Remark. A Recommendation must also accompany any currently charted features placed on the Disprovals layer.

- Example 1: The composite source includes a cluster of three features for deconfliction, one each from a prior survey, the raster chart and GC, positioned in close proximity to each other. The prior survey rock is found to be the best representation of the position of the rock. The prior survey rock maintains the original feature's registry number and date for SORIND and SORDAT. A Marker is included to note the results of the deconfliction. The remaining two features, the GC and chart rocks, are moved to the Disprovals layer, retaining their original SORDATs and SORINDs. Remarks are included for both, and a Recommendation accompanies the chart rock.
- Example 2: Where a LIDAR item is found by the field to be a charted feature, choose the better representation of the item. If the LIDAR item is selected over a charted item, the LIDAR item remains in to the Final_Features layer and the charted feature is moved to the Disprovals layer. If the charted item is selected over a LIDAR item, the charted item remains in the Final_Features layer and the LIDAR feature is moved to the Disprovals layer.

Where features from multiple sources are given in the composite source for deconfliction, and if deconfliction was either not attempted or was attempted but not achieved, (in other words, no edits were made to the features), the features will remain in Final_Features with the original SORDAT and SORIND. *All features in Final_Features that maintain their original SORDAT and SORIND must not also include Remarks or any other change to attribution. A Marker note will be useful in indicating that deconfliction was attempted but not achieved.*

- Example: The composite source includes a cluster of three features for deconfliction, one each from a prior survey, the raster chart and GC, positioned in close proximity to each other. A massive kelp bed prevented deconfliction. All three rocks are retained in the Final_Features layer without editing their SORDAT and SORINDs. A Marker note explaining that deconfliction was attempted will be useful to branch Cartographer's in determining proper application to the chart. Additionally, the extents of the WEDKLP area are digitized to Final_Features and assigned the new SORDAT and SORIND and a Remark.

Final_Features includes line features digitized to define new or modified limits of kelp beds, foul or rocky areas, ledges and reefs, where the extents were obtained using DPs, GPs, buffer lines, or Surfaces from VBES and/or MBES. Once the final Final_Features line or area feature is created, the new SORDAT and SORIND are assigned and a Remark added, for instance "New ledge". Reference DP's, such as $CSYMB features, are deleted from Final_Features once they have served their purpose. There is no need to reference the original DPs in the Remarks.

- Example 1 : The limits of a new area of kelp are defined in Pydro using $CSYMB point objects. Using the $CSYMB points in Notebook, a line is digitized to define the kelp area, assigned the new SORDAT and SORIND, and the Remarks field populated. The $CSYMB points used to digitize the feature are deleted.

- Example 2 : The BASE Surface is used as a back drop to digitize the extents of a rocky seabed area using a SBDARE line object. The SBDARE line object (which will be created as an area object during branch processing) is included in Final_Features and assigned the new survey SORDATs and SORINDs. Remarks are added to the line feature.

Final_Features includes new or modified point feature that were acquired in the field with either DPs or GPs and processed through Pydro. Where the DPs and GPs are collected as the S57 feature, (and not a cartographic symbol ($CSYMB) placeholder), they will be assigned the new SORDAT and SORIND in Final_Features.

- Example: A new rock is collected during shoreline verification and added to Pydro as UWTROC then imported to Notebook's Final_Features layer. The UWTROC feature is attributed with the new SORDAT and SORIND and its "new" status noted in Remarks.

Disprovals: HXXXXX_Disprovals.hob

Features from Composite Source that have been disproved should be moved from Final_Features to Disprovals, and should maintain the original SORDAT and SORIND. A Remark should indicate the reason for disproval. Disproved chart features also require a Recommendation.

- Example 1 : A charted rock is disproved using MBES. The charted rock is moved to Disprovals where it maintains the original SORDAT and SORIND, the Remarks field is populated regarding the method of disproval, and a Recommendation to remove the feature from the chart is made.
- Example 2 : A GC rock is found to be the westernmost extent of a new ledge. The new ledge is digitized to Final_Features and given the new SORDAT and SORIND and a Remark; the rock is moved to Disprovals where it maintains the original SORDAT and SORIND, and the Remarks field is populated regarding the GC rock disproval.
- Example 3 : The composite source includes a cluster of three features for deconfliction, one each from a prior survey, the raster chart and GC, positioned in close proximity to each other. The GC rock is found to be the best representation of the position of the rock. The GC rock retains the original SORIND and SORDAT and a Marker is included to note the results of the deconfliction. The remaining two features, the prior survey and chart rocks, are moved to the Disprovals layer. They retain their original SORDATs and SORINDs, Remarks are included for both, and a Recommendation accompanies the chart rock.
- Example 4: LIDAR coverage over a charted feature shows no indication of the charted feature. The feature has subsequently been disproved using VBES, SWMB, etc. The chart feature is placed on Disprovals where it maintains its original SORDAT and SORIND, and the method of Disproval is indicated in Remarks. A Recommendation id also required for all Disprovals. If a placeholder such as $CSYMB was used it is deleted from Final_Features.

In any case where the geographic position or shape is altered, a Disproval is required.

- Example 1 : A charted rock is found to be positioned 100 meters offshore of its true position. A new rock is digitized at the correct location on the Final_Features layer and assigned the new SORDAT and SORIND as well as a Remark. The original rock is moved to the Disprovals layer where it maintains the original SORDAT and SORIND, and the Remarks field is populated regarding the charted rock disproval. Because it is a charted feature a Recommendation is also required.
- Example 2 : A charted pile is discovered to be a dolphin 100 m to the west of the charted position. The new dolphin is digitized to Final_Features and given the new SORDAT and SORIND and a Remark; the pile is moved to Disprovals where it maintains the original

SORDAT and SORIND, and the Remarks field is populated regarding the disproval of the pile. Because it is a charted feature a Recommendation is also required.

- Example 3 : A ledge is found to extend 100 m offshore of the GC position, and in general, its shape is found to be different than shown. The correct geometry of the feature is digitized to Final_Features, and the feature is given the new SORDAT and SORIND and a Remark; the GC ledge is moved to Disprovals where it maintains the original SORDAT and SORIND, and the Remarks field is populated regarding the change.

In any case where the geographic primitive is altered (i.e., point feature modified to a line; point modified to an area, etc.), a Disproval is required.

- Example 1 : A charted rock is found to be a new reef. The new reef is digitized to Final_Features and given the new SORDAT and SORIND as well as a Remark describing the reassignment. The rock is moved to Disprovals where it maintains the original SORDAT and SORIND, and the Remarks field is populated regarding the charted rock disproval. Because it is a charted feature a Recommendation is also required.
- Example 2 : A charted obstruction area with snags/stumps is discovered to be the in tact wreck of the privateer Black Pearl. The OBSTRN object is moved to Disprovals, maintaining its original SORDAT and SORIND. It is given a Remark, and because it is a charted feature disproval, it is also given a Recommendation. A new WRECKS point object is digitized to the Final_Features layer and assigned the new SORDAT, SORIND and a Remark.

In any case where a section of the extents of a feature is modified, a Disproval is required.

- Example: The shape of a fragment of a GC reef is redefined using a buffer line. The fragment of GC reef to be modified is clipped out and moved to Disprovals where it maintains its original SORDAT and SORIND, and is given a Remark. The modified extent is digitized to Final_Features, assigned the new SORDAT and SORIND, and given a Remark.

In any case where only attribution is changed for any object, a Disproval is not required.

- Example: An eelgrass area is found to be kelp. The CATWED attribute is changed from sea grass to kelp. The WEDKLP feature is retained in the Final_Features layer, and the feature assigned the new SORDAT and SORIND, as well as a Remark explaining the change.

In any case where an object is modified to create a new feature of a different object class but with identical geographic position, geometry (shape), and geographic primitive (meaning point-to-point or line-to-line), a Disproval is not required.

- Example 1 : A charted pile is found to be a dolphin. The object remains on Final_Features. The PILPNT object class is changed to MORFAC, with CATMOR = dolphin. It is assigned a new SORDAT and SORIND and a Remark.
- Example 2 : An obstruction area with snags/stumps is discovered to be the scattered wreck of the SS Minnow. The OBSTRN area object is changed to WRECKS area object. The SORDAT and SORIND are modified to the new survey, and a Remark added.

4.5 Chart Comparison

Compare each hydrographic survey to the latest versions or editions of ENC's and raster charts in accordance with section 8.1.3., D.1 of the HSSD. The specific method of comparison is left to the discretion of the hydrographer, though the comparison is typically done using Pydro, CARIS, or MapInfo software. When performing a chart comparison, the hydrographer shall use the most current official charts available. If necessary or required by the Project Instructions, additional evaluation methods such as junction survey comparisons or prior survey comparisons may also be used.

4.5.1 Obtaining and Identifying Current Charts

The hydrographer should keep in mind that the most current official charts may not be the ones provided on the Project CD/DVD. Often, versions of raster and/or ENC charts used for vessel navigation will be more current. Any chart corrections from the National Geospatial Intelligence Agency's (NGA) Notice to Mariners (NTM), the United States Coast Guard's Local Notice to Mariners (LNM), and Canadian Hydrographic Service (CHS) that have not yet been applied should also be considered. For additional chart correction information, the database of NTM corrections can be queried online at: `http://www.nga.mil/portal/site/maritime`. LNM corrections can be reviewed online at: `http://www.navcen.uscg.gov/lnm`.

4.5.1.1 Raster Navigational Charts (RNC)

Prior to chart comparisons, the most current RNC can be downloaded from MCD at `http://nauticalcharts.noaa.gov/mcd/Raster/Index.htm`. For raster charts, the edition, corrections applied, and date of notices through which the chart has been "cleared" will be included in the *.KAP file header information, which can be viewed using a text editor such as WordPad. The term "cleared" means that all notices up to, and including, the one issued on the cleared date have been reviewed and any corrections applied to that raster chart. Edition and correction information has been identified in the example header file section in 4.5.1.1 .

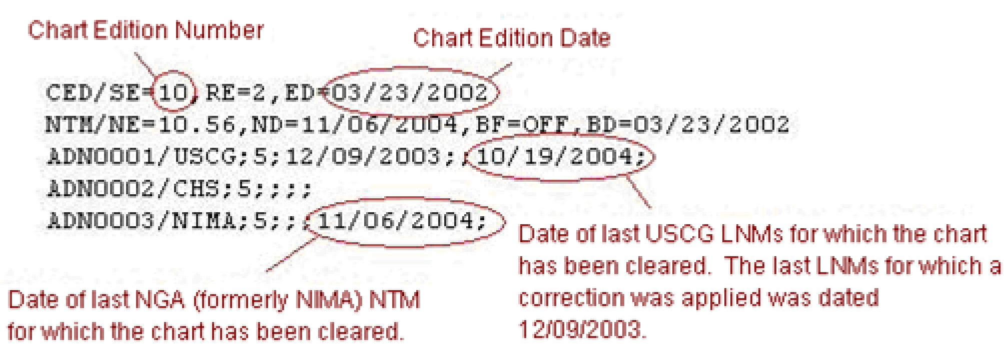

Figure 4.25: Section of a *.KAP file (opened in WordPad) identifying chart edition and corrections that have been applied to the digital file. Note: CHS does not issue corrections for this chart area, so no cleared date is listed.

Note: Some of the chart information identified in Figure 4.5.1.1 is repeated in the header line beginning with "NTM." In this example, NE=10.56 refers to what the raster manufacturer calls the "Notice Edition." It is the number of digital patches (56) applied to that chart edition (10). ND refers to the "Notice Date," and repeats the NGA NTM cleared date. BD is the "Base Date" and repeats the chart edition date.

4.5.1.2 Electronic Navigational Charts (ENC)

Prior to chart comparisons, the most current ENC can be downloaded from MCD at `http://chartmaker.ncd.noaa.gov/mcd/enc/download.htm`. If the user chooses the "Textual" option for downloading ENCs, each cell will be listed as shown in Figure 4.5.1.2 . By using this option, the hydrographer can view and record the Update Application Date and Issue Date for each ENC cell.

Click Image	Chart	Title	Ed.	Update Application Date	Issue Date	Cell Name	Select
	13278	Portsmouth to Cape Ann	3	2005-04-19	2005-06-29	US4MA04M	☐

Figure 4.26: Sample ENC listing when using the "Textual" option to download files.

The ENC Update Application Date is the date that the full ENC Cell was first posted or re-posted. This date is similar to the Edition Date of a raster chart. ENC Cells are re-posted when the updates grow too large or a large section of the Cell is re-built. The Issue Date identifies when the last correction was applied. All notices have been applied through that date, similar to a "cleared" date for raster charts. If using an ECDIS system or viewer software to read the ENC, these dates can be found in the ENC Cell properties.

Note: Some viewer manufacturers have erroneously reversed the Update Application Date and Issue Date. Since an edition must exist before it can be corrected, the later of these two dates will always be the Issue Date.

4.5.2 Junction Survey Comparisons

If the designated limits for a survey junction with modern data from another survey, the area of overlap should be compared and discussed in the Descriptive Report. OCS considers a standard junction comparison acceptable if sounding variance is 1 meter or less between the present and junctioning surveys. Agreement is considered poor if sounding variance is greater than 1 meter. In such cases, the hydrographer should attempt to determine the cause(s) of significant discrepancies and explain these variances in the Descriptive Report.

4.5.3 Prior Survey Comparisons

Due to the advances in survey technology and data coverage capabilities, modern survey data will nearly always supersede historical data. Thus, prior-survey comparisons are generally not required by field personnel, but may be used at the discretion of the hydrographer for quality control purposes. If the present survey has numerous conflicts with charted soundings and/or features, then the hydrographer should consider conducting a prior survey comparison. If a prior survey comparison is performed, the reason it was deemed necessary should be discussed in the Descriptive Report and the applicable prior survey(s) should be identified by registry number, date of survey, and scale.

Chapter 5

Data Management and Survey Deliverables

Don't agonize. Organize. – Florynce Kennedy

The purpose of this chapter is to define data management and deliverable requirements for NOAA field units conducting OCS hydrographic surveys. These requirements have been established to safeguard hydrographic data during field operations, support efficient office processing, and expedite the application of survey data to NOAA's navigational products.

5.1 Data Management

A typical OCS hydrographic survey produces an extensive amount of data; thus, proper data management is critical. Two primary components of data management are addressed in this chapter: data security, releasability, storage, and data filing and organization. It is the field unit's responsibility to manage all survey data such that its security and integrity are not compromised during operations, and to efficiently transmit these data to AHB, PHB, or other designated recipient(s).

5.1.1 Data Security, Releasability and Storage

Hydrographers should take special care to insure that hydrographic data security is carried out and released according to OCS policy. All hydrographic personnel should also always consider possible liability issues that may be associated with dissemination of preliminary data. Further guidance is given below in this section and contact information for these authorities will be identified in the Project Instructions.

Additionally, data and reports generated while conducting OCS hydrographic surveys are official records that must be cataloged and archived. Since the majority of these data and reports are in digital format, a field unit's digital data storage systems must be configured, operated, and maintained with care. Precautions should be taken against data loss due to careless handling, accidental corruption, or system failure.

5.1.1.1 Data Security

It is the field unit's responsibility to maintain all survey records in a manner that ensures data is accessible only to the appropriate survey personnel and system administrators. Tracking procedures should be used to identify which personnel have performed specific tasks for all data acquisition, processing, and manipulation. Data security can be maintained within a field unit via a combination of procedural checklists and logs, as well as establishing computer user accounts with password protection.

Frequently, field units will receive requests for survey data from constituents and private parties. Field units shall obtain approval from the Chief-of-Party prior to releasing any preliminary data or products to parties outside of OCS.

Note: Any preliminary data product released must be clearly annotated in accordance with 5.2.3.4 of this manual.

A copy of all products released to the public shall be included in the Public_Relations_&_Constituent_Products folder of the survey submission package. The field unit shall document all survey records or constituent products officially transmitted using a digitally signed NOAA standard form Letter Transmitting Data (NOAA Form 61-29), which can be created in Pydro. A record of all transmittal letters created and received should be maintained by the field unit.

5.1.1.1.1 Special Data Handling Requirements Special handling requirements will be described in the Project Instructions from HSD Operations Branch. Examples of situations requiring special data handling are below.

The acquisition, handling and release of high-resolution bathymetry (HRB) in US Navy submarine security zones deeper than 50 meters are subject to approval and restriction by the US Navy's HRB Review Panel. The memorandum of agreement between NOAA and the HRB Review Panel (included in Appendix 5) details the areas subject to approval and restriction by the US Navy and provides data handling guidance for HRB data and derived products.

All newly discovered uncharted shipwrecks are to be treated as significant and vulnerable historic resources. This treatment entails following the data handling guidance in 4.4.5 of this manual.

Certain homeland security survey data have special handling requirements prescribed by the US Naval Oceanographic Office and OCS. Those requirements are described in the following documents included in Appendix 2:

- NAVMETOCCOMINST 3142A March 2007.pdf
- NAVMETOCCOMINST 3142A March 2007 - OCS Deviations.pdf

Raw or processed data from sources external to NOAA are not to be made available to the public at any time.

5.1.1.2 Data Releasability

Field units or HSD/NSD office personnel should be aware that the policy information mentioned here is set such that the release of raw or working data do not provide a company an unfair competitive advantage within its industry or carry with it liability issues that may be associated with the dissemination of this data. These policies are also set to adhere to the National Historic Preservation Act of 1996 and the Archaeological Resources Protection Act of 1979. Information about all newly uncharted navigationally significant and potentially historical man-made features , particularly position coordinates, is considered sensitive material and this information shall not be released to the general public without first notifying designated local, state, or federal management authorities (refer to 2.4.4.1 and 4.4.5).

Figure 5.1 illustrates a general flow diagram of HSD's processes to plan hydrographic surveys, acquire, process, quality control and compile hydrographic data to create products.

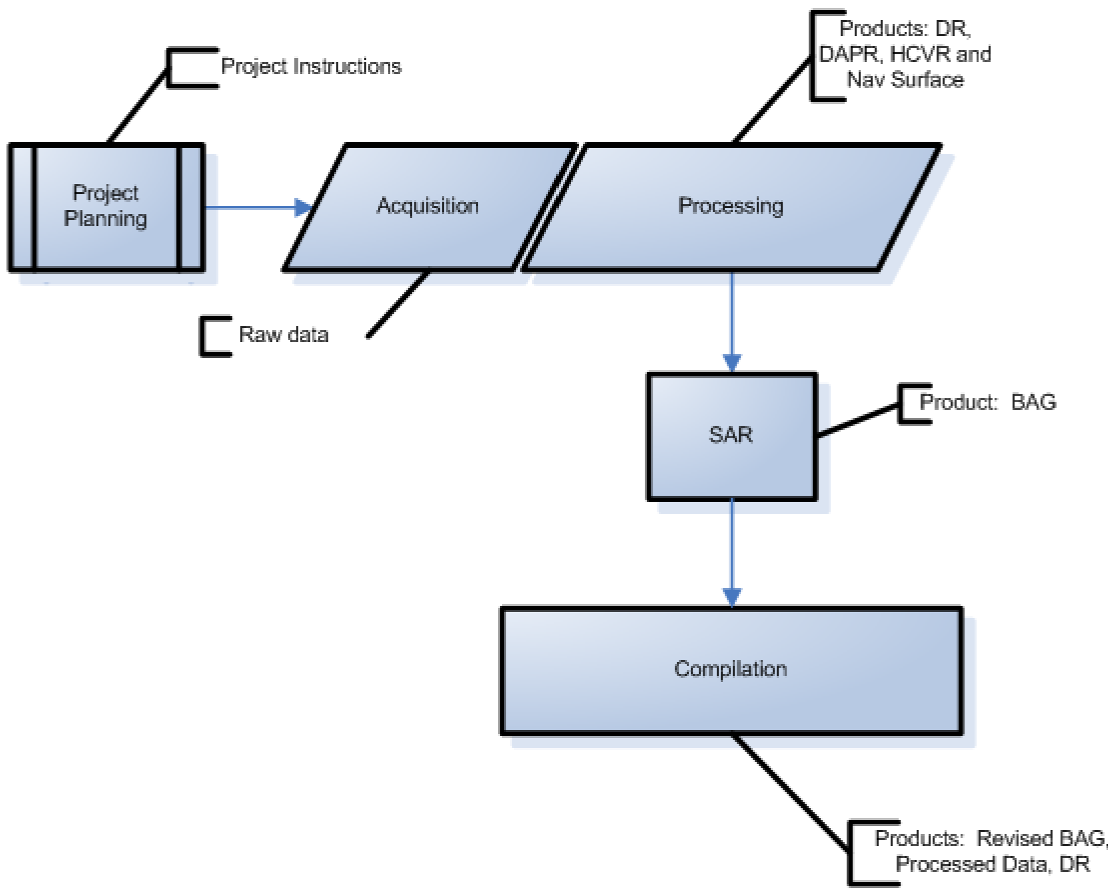

Figure 5.1: General flow diagram of HSD's processes.

According to the draft OCS Policy for the Release of Mission Data, included in the Chapter 5 Appendices, there are three defined stages for Mission Data (see the OCS policy for more information about each of these stages):

- Raw Data: data as it is originally collected manually, from sensors, or received from other sources such as other federal agencies.
- Working Data: data on which processing has been performed that changes the information contained in the data but which is not yet processed to a level deemed as complete and suitable for public release (e.g. data that has undergone a Survey Acceptance Review (SAR).
- Data Product: data which has been processed or accepted without further processing which is considered to be, suitable for release to the public, and which OCS acknowledges as official (e.g. BAG after approval).

Due to the increase in requests for digital data at all stages, HSD has been working with the National Geophysical Data Center (NGDC), which stores this data, to release the data to the public at the following stages in HSD's pipeline:

1. After AHB/PHB has received the raw data from the ships and have sent the data to NGDC.
2. After the working data has undergone a SAR and AHB/PHB has sent it to NGDC (Post-SAR).
3. After OCS acknowledges the data as official[1].

ONLY DATA AT NGDC CAN BE RELEASED TO A REQUESTOR. HSD/NSD office personnel, responding to a request, should direct the requestor to a point of contact at NGDC (which can be identified by HSD). Official data is available via NGDC's website `http://map.ngdc.noaa.gov/website/mgg/nos_hydro/viewer.htm` (NGDC will have a website for the public to retrieve raw or post-SAR data in the future).

It should be noted that field units shall NOT release raw or processed data to a requester outside of OCS. Also field units shall NOT create specialized products in response to a data request unless authorized by their supervisor. Data requests for processed data which are still on the vessel must comply with the guidance in 5.2.3.4 of this manual and ensure that an effort should be made to meet the needs of the requester without being unduly time consuming.

If the Chief Hydrographer feels the requester has reasonable cause to warrant the release of raw data which are still on the ship and have not been sent to AHB/PHB then, (s)he must obtain written approval by the appropriate Division Chief (i.e. the Chief, Hydrographic Surveys Division or Chief, Navigation Services Division) to release these data. Raw data, if release is approved, should be distributed with a disclaimer describing, in general:

- Things that have not been done (e.g. list correctors that haven't been applied).
- Uses of the raw data that are not appropriate.
- Anything else the Chief Hydrographer or Chief of HSD feels necessary to include.

Additionally, metadata should be provided in conformance with applicable standards and such metadata should be entered in to the appropriate national metadata data base. Finally, an official record of raw data distributions shall be made and preserved (contact the Chief of HSD/NSD for more information).

Likewise, if the Chief of AHB/PHB is forced to distribute Post-SAR (working data) or feels the requester has reasonable cause to warrant the release of processed data which are in line to undergo a SAR, field units or HSD/NSD office personnel responding to a request must obtain written approval by theappropriate Division Chief to release this data. Post-SAR data, if release is approved, should have a strong disclaimer letter that accompanies the data and indicates enough major flaws to discourage its use and further requests. Additionally, before releasing this data three steps should be taken:

1. The data or a transmittal document shall be marked appropriately taking into consideration the recipients intended use. Suitable markings might be: 'Preliminary Data – contents may change', or 'Draft – not to be used for navigation', or 'Working file – processing has not been completed and significant corrections may yet be applied'.
2. The recipient shall be counseled as to the known condition of the data, the nature of possible changes, and other known considerations that would help the recipient use the data in a prudent manner.

[1] All personnel should note that all new data will be in the BAG format instead of the previously archived ascii xyz format. The BAG format was developed to create an open source exchange format for gridded data therefore any public requestor should be able to use data in this format (see section 5.1.1.3 of the HSSD)

3. The provider should mark the data set or accompanying transmittal document indicating to whom the file was provided, and that the recipient was counseled as to the status of the data. The provider shall then prepare and preserve an official record (contact the Chief of HSD/NSD for more guidance – this should be in line with how NGDC records requests) that data was provided, to whom, for what use, on what date, that counseling was provided, and who made the determination and released the data.

5.1.1.3 Data Storage

All storage devices and media used for OCS hydrographic survey data should be approved by HSD and/or HSTP. Field units shall not implement new data storage technology or media without first consulting HSD and/or HSTP to verify that the system is both based on proven technology and is compatible with equipment at other NOAA sites that may need to access the survey data.

NOAA's hydrographic survey ships are typically equipped with Network Appliance (NetApp) data storage systems. The NetApp system consists of dual RAID (Redundant Array of Independent Disks) arrays with independent control heads. Each NetApp system should be set up in a mirrored crossover configuration with daily and weekly snapshots to provide data redundancy and recoverability in case of partial system failure. With this type of system redundancy, if one control head fails, the second will assume control of both RAID arrays; if one RAID array fails completely, a copy of the data will remain on the second RAID. Data recoverability is provided by "point-in-time" snapshots of the data that can be used to restore directories that have been inadvertently deleted or become corrupt. OCS strongly recommends physically separating the two NetApp control heads to prevent catastrophic data loss due to a point event such as an isolated fire.

Navigation Response Teams use a different type of data storage system to meet their specific mission needs. Typical NRT data storage systems consist of one NAS (Network Attached Storage) unit that is regularly backed up onto an external hard drive. This type of system combination should be configured to automatically compare the two drives for differences periodically throughout the day. If any new data are found on the NAS, those files should be automatically mirrored onto the external hard drive.

5.1.1.3.1 Data Backup Requirements Regardless of the data storage system used, each NOAA hydrographic field unit must ensure that all survey data that have not been previously submitted to, and accepted by, either AHB or PHB are routinely backed up. Backups shall be performed such that a complete systems failure would result in no more than one day of data lost. For example, weekly full backups and daily incremental backups (using a tape scheme) would ensure that the maximum loss of data would only be those files modified or created in the time between the previous incremental backup and the failure. The method used to backup data may vary and could include a tape system, CDs, DVDs, or redundant drive system. Many backup systems, such as the NetApp, can be configured to perform scheduled backups automatically. It is the responsibility of the field unit to verify that their backup solution is operational throughout the field season.

Note: If using a NetApp system, OCS recommends it be configured to retain 6 daily snapshots and 2 weekly snapshots, providing access to files up to 20 days old (best case).

5.1.1.3.2 Data Transfer Data can be transferred from field units using a variety of media, including CDs, DVDs, various types of tapes (DLT, DDS, AIT, LTO), and portable hard drives. However, field units should ensure that data transfer media is compatible with the data recipient's equipment. Regardless of the method used for data transfer, there will always be a risk of damage, loss, or corruption of data during the transfer process. OCS recommends that field units retain a backup of any data transmitted until a successful transfer has been confirmed by the recipient.

When survey data have been submitted to AHB or PHB, field units are required to retain a backup of this data until the hydrographic branch has acknowledged that the data have been successfully archived and the 30-day survey review has been completed. Even after data has been successfully transferred, OCS recommends the field unit retain copies of final survey products created (e.g., PSS, DR, MapInfo tables, public outreach materials, etc) on removable storage media such as CD or DVD if additional operations will be conducted in that general project area.

5.1.2 Data Filing and Organization

Due to the quantity of data generated during an OCS hydrographic survey, standardized data filing and organization practices should be used. These methods may vary among field units during data acquisition and processing, but it is imperative that a standardized system be used across all field units for data submission to AHB and PHB. Clearly named files, standardized directory structures, and common practices will all contribute to efficient data management and survey processing.

5.1.2.1 Field Unit Data Directory Structure

It is very important for a field unit to establish a working data directory structure that is consistent across the data acquisition and processing computers and storage devices throughout the unit. When designing a working directory structure, any specific software requirements must be considered. For example, CARIS HIPS/SIPS data must be configured with a specific directory structure so that referenced information can be accessed by the software. An expanded view of a sample CARIS directory structure is shown in Figure 5.2.

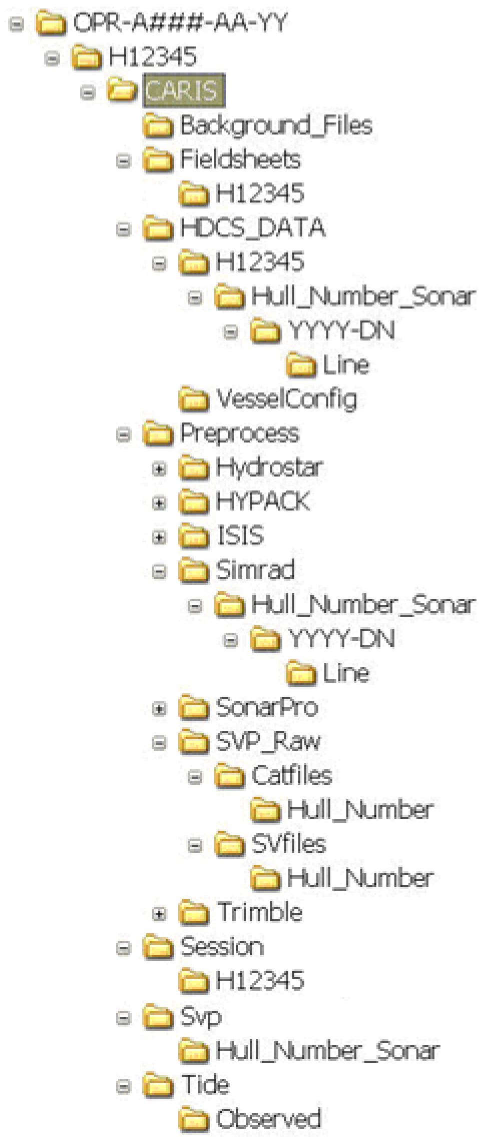

Figure 5.2: Field unit data directory structure.

OCS recommends that field units store raw and post-processed data in separate directories. Typically, raw data will be organized by survey registry number with subfolders further sorting the data by acquisition system type, then by vessel (HVF name), by day, and finally by line. This type of file structure is referred to as PVDL (Project/Vessel/Day/Line).

Note: The “vessel” subfolder name must be identical to the CARIS HIPS Vessel File (HVF) name for the data it contains.

Post-processed data are typically organized by survey registry number and then subdivided according to the directory structure required by CARIS HIPS/SIPS software.

Raw data files are often quite large. As a result, storage of raw data may become unmanageable if many surveys are in progress at once. In such cases, the field unit may transmit a survey’s complete raw data set to AHB or PHB prior to submission of the remaining survey records. The field unit shall follow standard data submission procedures if submitting raw data files separately. Once the field unit receives notification from the receiving Hydrographic Branch that all data have been successfully archived, the field unit may remove the corresponding raw data from their system.

5.1.2.2 Survey Data Submission Directory Structure

Since surveys are submitted to the hydrographic branches from several NOAA field units and each survey includes data from numerous sources, standardized data submission practices shall be used to support efficient office processing and verification. The standard file structure to be used by NOAA field units when submitting OCS hydrographic survey data to either AHB or PHB is outlined below, with a brief description of each section. A pictorial representation of this file structure is shown in Figure 5-3 on the following page. Specific survey deliverables are discussed in 5.2. See appendix 5 for a digital data submission checklist.

Note: If files to be included in a specific subfolder have either not been generated at the time of data submission or are not required for a specific survey, the subfolder shall not be eliminated from the directory structure even though it is empty. By maintaining the complete submission directory structure, a data recipient can quickly verify that no items have been overlooked or inadvertently moved/deleted.

5.1.2.2.1 Field Unit_YYYY (e.g., RAINIER_2006) This folder shall be named to identify the field unit and year of data submission. It should contain any pertinent information that applies to all hydrographic survey data acquired by that unit over the course of the year specified. At a minimum, the following subfolder shall be included:

- ◦ HSRR - Include a digital copy of the field unit's Hydrographic Systems Readiness Memo and corresponding Hydrographic Systems Readiness Acknowledgment as defined in Chapter 1 of this manual.

5.1.2.2.2 H12345 This folder shall be named to identify the registry number of the survey being submitted. It should contain only survey-specific data and reports that have been approved for submission by the Chief-of-Party. At a minimum, the following subfolders shall be included:

- ◦ CARIS - This folder shall include all final survey data and any supporting files used to correct data during post-processing.
  - ◦ Background Files - Include in this folder any background files that support final CARIS sessions submitted with the survey.
  - ◦ Fieldsheets - This folder shall include the following CARIS fieldsheet(s). All preliminary fieldsheets should be removed from this folder prior to data submission.
    - ∗ H12345 - This fieldsheet should contain all finalized BASE surfaces and mosaics for the survey. If, for data manageability, multiple fieldsheets are necessary to represent final survey data, fieldsheets should be named such that the contents are easily inferred (e.g. H12345_SSS). Each BASE surface should be named such that the survey registry number, BASE surface resolution, and depth range are identified (e.g., H12345_0p5m_0to5m). Each mosaic should be named such that the survey registry number, mosaic resolution, and SSS percentage are clearly identified. For example, a first 100% SSS mosaic at three meter resolution would be named H12345_3m_100. A corresponding 200% SSS mosaic would be named H12345_3m_200.

  - HDCS_DATA - This folder shall contain all post-processed data generated in CARIS for the survey being submitted. Data shall be further organized using subfolders to create a Project/Vessel/Day/Line (PVDL) structure, as required for use with CARIS software. All extraneous data shall be removed from this folder prior to data submission.
    - VesselConfig - This folder shall include copies of each HIPS Vessel File (*.HVF) used to process data for the survey and any applicable DeviceModels.xml files. Any modifications made to these files during survey operations should be documented in the corresponding Descriptive Report.
  - Notebook Files - Include in this folder any final stand-alone Hydrographic Object Binary (*.hob) files created in CARIS Notebook and any additional supporting files requested by the hydrographic branch receiving the survey.
  - Preprocess - This folder shall contain all pre-processed (raw) sonar and sound speed profile data acquired for the survey. Raw sonar data should be organized by acquisition system, vessel (HVF name), and day number. For example, if mainscheme MBES data was acquired by RAINIER on 27 June 2006 for survey H12345, the file structure might be: *H12345_MBES > RA_S221_Elac1050D > 2006_178*. If rejected and/or nonconverted sonar files are submitted they should be contained in a separate folder designated for that purpose. Raw sound speed profile data should be separated into subfolders by vessel hull number and day. The configuration file (*.con) for each sound speed profiling instrument used for survey operations must be included in the Preprocess folder.
  - Session - Include in this folder any final CARIS Sessions requested by AHB or PHB for the survey. Each Session should be named such that its contents can be easily inferred.
  - SVP - This folder shall include only the processed CARIS *.svp files applied to the survey data being submitted. Files should be separated into subfolders by vessel hull number and day.
  - Tide - This folder shall include only the tide zone file (.zdf) and tide/water level (*.tid) files applied to the survey data at the time of submission. Files should be named so that the type of tide/water level data (i.e., predicted, preliminary, verified or final) is identified.

- Descriptive Report - This folder shall contain all digital Descriptive Report files for the survey. These files include the report body, a digitally signed Approval Sheet created in accordance with the HSSD, and files for each Appendix and Separate as described below. For additional information on digital signatures please refer to SOP_Digital_Signatures.pdf in Appendix 5. Note: The contents of Appendices and Separates indicated in this manual may differ slightly from requirements defined in section 8.1.3 of the HSSD based on in-house software and surveying practices. For all NOAA field units, the submission requirements set forth in this manual shall supersede those in the HSSD unless otherwise specified by the Project Instructions.

  - Appendices - This folder shall contain a subfolder for each Appendix identified below. Additionally, a single comprehensive Appendices file in .pdf format (e.g., H12345_Appendices.pdf) will be included in the Appendices folder. This file should contain, in chronological order, all .pdf files in the Appendices subfolders with a digitally signed title page for the complete document and a title page for each individual Appendix.
    - I. DTON_Reports - This folder shall contain all Pydro generated DTON Reports (Zip archives containing *.pdf and *.xml files as well as the DTONImages folder) submitted to MCD for the survey and a copy of corresponding email response(s) from MCD confirming that DTON data was received and processed.

- II. Survey_Feature_Report - This folder shall contain the "For Descriptive Report" feature report generated in Pydro. This file should be named to identify the survey number (e.g., H12345_feature.pdf). Note: All Pydro PSS Metadata fields should be completed prior to generating the feature report so that this information will be included in the document generated.
- III. Final_Progress_Sketch_&_Survey_Outline - This folder shall contain the final Progress Sketch for the survey and all Survey Outline MapInfo tables generated using the Survey Outline Instructions provided on the Project CD/DVD.
- IV. Tides_&_Water_Levels - This folder should contain all tide and water level records, reports, and correspondence specific to the survey. The official smooth tide note, issued by CO-OPS to identify which files must be used as final correctors, shall be included in this folder as well as the *CORP.tab, *STNP.tab, and *LABP.tab files applied to survey data for projects using disctrete zoning to obtain tide correctors (those three files do not exist for projects using TCARI to obatain tide correctors). At a minimum, the following subfolder shall also be included:
  - Request_For_Tides - This folder shall contain a copy of the Pydro generated Request for Tides package. This package will consist of a *.pdf, *.mif, and *.mid file.
- V. Supplemental_Survey_Records_&_Correspondence - This folder shall be used for any additional survey records not previously addressed in the Descriptive Report, Appendices or Separates. Copies of transmittal letters and/or any correspondence relating to the present survey should be included.

○ Report_Body - This folder shall contain the official Descriptive Report cover page (NOAA Form 76-35A), Hydrographic Title Sheet (NOAA Form 77-28), and descriptive report body. The cover page and Hydrographic Title Sheet may be generated in Pydro and submitted in *.pdf format. The report body shall be submitted in Microsoft Word format and named according to the survey registry number (e.g., H12345.doc.)

- Approval_Sheet - This folder shall contain a digitally signed Approval Sheet as defined in section 8.1.3 of the HSSD. Digital signatures have been approved by OCS and shall be used on all survey Approval Sheets.

○ Separates - This folder shall contain a subfolder for each Separate identified below. Additionally, a single comprehensive Separates file in .pdf format
(e.g., H12345_Separates.pdf) will be included in the Separates folder. This file should contain, in chronological order, all .pdf files in the Separates subfolders with a digitally signed title page for the complete document and a title page for each individual Separate.

- I. Acquisition_&_Processing_Logs - This folder shall contain all acquisition and processing log files and any detached position forms associated with the survey being submitted.
- II. Sound_Speed_Data - Include all digital DQA records associated with the survey being submitted. Velocwin software automatically generates a digital DQA record for each project (e.g., OPR-A###-AA-YY.DQA) and appends to this file when DQA tests are performed. Refer to 1.5.3.3 .
- III. Hydrographic_Survey_Project_Instructions - Include a digital copy of the Project Instructions and all amendments (changes, documented telephone conversations, and email correspondence) that pertain to the survey being submitted.
- IV. Checkpoint_Summary_&_Crossline_Comparisons - This folder shall contain documentation to support a mainscheme to crossline comparison performed in accordance with section 5.1.4.3 of the HSSD. Two possible methods of conducting the crossline analysis are a beam by beam statistical analysis or a surface difference. A beam by beam analysis can be performed in Pydro by creating an appropriate number of checkpoints then generating a "Points/Surface Stats" report. Since

section 5.1.4.3 only requires a general evaluation the reports generated by Pydro or CARIS can be done by the field but they shouldn't be submitted with the deliverables..

- Public Relations and Constituent Products - This folder shall contain survey related products generated by the field unit for dissemination to other NOAA offices or outside organizations. Include any final MapInfo tables and workspaces for plots, "one-pagers" (in *.pdf format) created for public relations, and any other preliminary products released to constituents, navigation managers, or the public in the native format provided.
- PSS - This folder shall contain any images or digital photographs that are associated with Pydro features but are not standard CARIS-generated side scan sonar contact images, which are automatically included in the CARIS HDCS data files. Images should be in *.jpg format and named to correspond with the associated feature.

5.1.2.3 OPR-A###-AA-YY

This folder shall be named to identify the project number under which the submitted survey is assigned. It should contain subfolders for documents and reports that apply to all surveys completed for a given project over the course of the year specified. At a minimum, the following subfolders shall be included:

- Coast_Pilot_Review - Include a copy of the revised Coast Pilot text created in accordance with the Coast Pilot Review procedures outlined in 3.5.6. Any pertinent supporting information should also be included in this folder.
- Data Acquisition and Processing Report (DAPR) - Include the Data Acquisition and Processing Report for the project (in *.pdf format) and any supporting information as defined by the HSSD. The DAPR file should be named according to the project number (e.g., OPR-A###-AA-YY_DAPR.pdf.)
- Horizontal and Vertical Control Report (HVCR) - Include the Horizontal and Vertical Control report for the project (OPR-A###-AA-YY_HVCR.pdf) and any supporting information as defined by the HSSD and 5.2.3.2.3 of this manual. No report is necessary if no HorCon and/or VerCon were conducted; however, a text document stating that no HorCon and/or VerCon operations were conducted shall be placed in this folder in lieu of an HVCR.

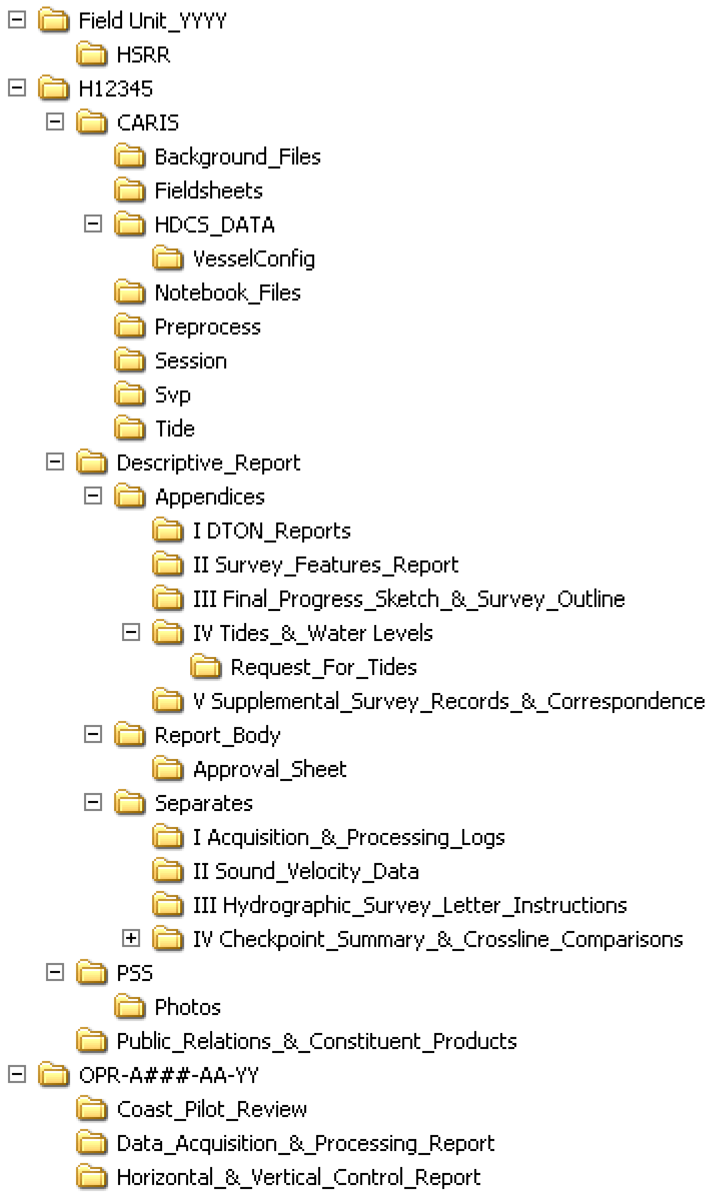

Figure 5.3: Submission directory structure.

5.1.2.4 Naming Conventions

It is critical that file naming conventions be standardized to quickly communicate what information a file contains. Therefore, several standard file names are specifically identified in this manual. As a standard practice, use the survey registry number (H12345) rather than sheet letter designations when naming survey files. Any files submitted that will be unfamiliar to the receiving hydrographic branch and/or do not follow standard naming conventions shall be accompanied by a separate digital text document fully describing the file(s). This text file shall be named “read me”, with an appropriate extension, and should be located at the top level of the directory structure containing the unfamiliar or non-standard files.

5.2 Survey Deliverables

Survey deliverables refer to all data, reports, and products associated with an OCS hydrographic survey that will be approved and submitted by a NOAA field unit. When submitting a survey to AHB or PHB, the data deliverables shall include all data and information necessary for office verification, including the ability to manipulate data if necessary, thorough documentation of the field unit's survey procedures, and results and recommendations for the survey. Some survey deliverables, such as DTON Reports, the Request for Tides, Coast Pilot Review, and NODC files, have additional and/or unique submission requirements. All required OCS hydrographic survey deliverables and any specific submission requirements are briefly described in the following sections.

5.2.1 Digital Data

If possible, all data shall be submitted to AHB or PHB in digital format. This requirement includes documents that can be easily scanned into *.pdf files, such as memos, system calibration reports, and DP reports. Digital data shall be submitted using the directory structure described in 5.1.2.2 and illustrated in Figure 5.3 . Only data that pertains to the survey being submitted should be included in the digital data deliverables. All preliminary, temporary, or working data files shall be removed prior to submission.

Prior to submitting digital data, the field unit should verify that all files are present and none have become corrupt during transfer to a portable media. A digital directory listing of data on the transfer media should be created and compared to the original file structure. Include this directory listing, as a text file named to reference the transmittal letter number, in the data submission package. This directory listing can be generated and automatically sent to a text file by typing "dir /s submission directory name > transmittal reference number.txt" (e.g., dir /s H12345 > RU-2-06.txt) at the Windows Command Prompt.

To ensure that a complete data recovery is possible in case of lost mailings or media problems, the procedures below shall be followed by each field unit when submitting final digital survey data to AHB or PHB:

- Verify that backups of all data being submitted have been made and are securely stored. Backups must be in a format that can be readily restored at the receiving Hydrographic Branch.
- Review the content of all back ups and deliverable digital media to ensure they are complete, accurate, and structured in accordance with OCS specifications.
- Retain the backup for a survey until notified by AHB or PHB that the data have been successfully archived and the 30-day survey review has been completed.

5.2.2 Analog Data

In some cases, it may be necessary to submit analog data (i.e., paper records) that can not be readily scanned into a digital record, such as a VBES fathogram. This type of data shall be filed in a folder and accompany the digital data package. Each record should be labeled with survey number, date, data type, and any other pertinent information.

5.2.3 Reports and Field Products

Various reports and field products will be generated in conjunction with an OCS hydrographic survey. Survey reports can be divided into three tiered categories. Field Unit Reports refer to those providing information that encompasses the entire field unit and its operations. Project Reports are those containing information that applies to all surveys completed (or to be completed) within a project for a specific year. Project Reports may reference information contained in Field Unit Reports, provided the referenced document is clearly identified and readily available for review. Survey Reports contain information specific to only one survey and may reference information contained in both Field Unit Reports and Project Reports, provided the referenced documents are clearly identified and readily available for review.

This section of the FPM provides an overview of reports and products to be submitted in conjunction with every OCS hydrographic survey completed by a NOAA field unit. Each of these reports shall be delivered to the hydrographic branch that supports that field unit unless a different recipient is explicitly identified either in this manual or the Project Instructions.

5.2.3.1 Field Unit Reports

5.2.3.1.1 Hydrographic Systems Readiness Review (HSRR) Memo The only OCS-mandated Field Unit Report is the annual Hydrographic Systems Readiness Review (HSSR) Memo (see Appendix 1). The HSSR Memo is to be submitted on an annual basis within 10 working days of commencing survey operations at the start of the field season. Details on the submission of the HSRR Memo are in 1.1.1.

5.2.3.2 Project Reports

5.2.3.2.1 Monthly Survey Progress Estimates, Project Statistics and Vessel Utilization Reports Monthly Survey Progress Estimates (formerly Progress Sketch), Project Statistics and Vessel Utilization worksheets shall be submitted as one workbook to progress.sketches@noaa.gov in accordance with the guidance below by the fifth day of the month following survey operations. To assist in the submission of this information, HSD Operations Branch will provide each ship with a Monthly Report Excel file with three separate worksheets as indicated below. A sample progress report can be found in the appendix to chapter 5.

Survey Progress Estimate – This will be used to track estimated monthly survey progress by area within a given month. It will be a spreadsheet that consists of rows showing the vessel's current project and all associated survey sheets. Column titles are self-explanatory. For each month that data is acquired on a survey sheet (as well as sheets that are still incomplete) the *cumulative* percentage completed through the end of that month should be entered in the spreadsheet. Any modifications to the initial survey sheet layout must be reported.

Project Statistics – This will be used to track monthly statistics other than square nautical miles. Since each row of the spreadsheet represents a specific project within a given month, the field is advised to maintain one sheet for the entire fiscal year and submit the updated version every month. The following provides clarification of the columns within the spreadsheet:

- The "LNM VBES" (vertical beam echo sounder), "LNM MB" (multibeam), and "LNM SSS' (side scan sonar) are for the purpose of reporting operations using only one sonar sensor.
- The "LNM Combo" is for reporting LNM if a combination of sensors is used., such as side scan and single beam or multibeam and side scan.
- The LNM above are to be subdivided between ship and launch platforms as appropriate.

- “Items Investigated” includes the number of AWOIS items or newly discovered items that require extra survey time.
- “Tide Gauges Installed/Removed” and “Bottom Samples” are the only other stats needed from NOAA survey vessels. Contractors are still required to report Days at Sea (on site working on the project) and days (or fraction of days) lost due to weather or equipment malfunction.

Vessel Utilization Report – This is a new standardized format of a requirement that has been used over the past three years. The purpose of this form is to collect data that will highlight the areas that are having the greatest effect on productivity and may be in need of additional resources. A template with example data is included in the Appendix 5. A brief description of the various columns is below:

- Comment – short description of survey activities and lost productivity.
- Days at Sea (DAS) – as defined by the Office of Marine and Aviation Operations (Any day in which a vessel is at sea for at least 1 hour during a 24-hour period in support of an assigned project. DAS include days or arrival and departure, times anchored (except during port calls) or hove-to drifting on the working grounds, and occasions when a survey ship (even though moored) deploys 25 percent or more of its total complement including officers and crew in field survey activities.)
- Transit (hours) – ship travel time from port to the project area or within the project area (i.e from one anchorage to another – does not include launch transit time between ship and survey area). Transit hours are in support of surveys but should not be counted as planned/actual survey hours
- Ship/launch planned and actual survey hours – number of hours planned for each platform if all equipment is operating properly and if the authorized number of skilled personnel are available; the number of actual hours worked for each platform.
- Vessel Utilization – percentage (rounded to the nearest decimal) of planned hours that were actually worked; this number should not be affected by time lost due to routine mechanical/electrical maintenance or safety stand down days.
- Weather/Safety Stand down (hours) – hours of production lost due to weather or safety stand down (divided between ship and launches)
- Unscheduled Maintenance or Equipment Issues (hours) – hours of production lost due to unscheduled repairs to non-survey equipment.
- Downtime due to Survey Equipment Issues (hours) – hours of production lost due to problems related to survey equipment.
- Downtime due to Personnel Shortage (hours) – hours of production lost due to shortage of personnel or shortage of personnel with requisite skill level.

It is understood that the determination of planned survey hours is very subjective and dependent upon numerous factors including the requirement to process acquired data in a timely fashion and the availability of vessels and personnel.

5.2.3.2.2 Data Acquisition & Processing Report (DAPR) A Data Acquisition and Processing Report shall be created to describe the data acquisition and processing procedures, quality control procedures, and any major deviations from OCS standard survey practices implemented throughout a project. The DAPR shall be completed in accordance with section

8.1.4.1 of the HSSD and submitted to the Chief of HSTP and the hydrographic branch that will be receiving data for the project. The DAPR should be submitted simultaneously with, or before, the first survey of the project completed that year. Note: For projects that span multiple years, a new DAPR shall be generated each calendar year. Information contained in the HSRR may be referenced in the DAPR to meet reporting requirements set forth in the HSSD.

5.2.3.2.3 Horizontal & Vertical Control Report (HVCR) The Horizontal and Vertical Control Report shall be completed in accordance with section 8.1.4.2 of the HSSD and submitted to the appropriate hydrographic branch before or not later than the submission of the last survey of a project. For projects that span multiple years, a new HVCR shall be generated each calendar year. No report is necessary if no HorCon and/or VerCon were conducted; however, a text document stating that no HorCon and/or VerCon operations were conducted shall be placed in this folder in lieu of an HVCR.

5.2.3.2.4 Tide & Water Level Data Package Field units that have installed and serviced water level stations in support of an OCS survey project shall provide the following Tide and Water Level Data Package to CO-OPS in accordance with section 4 of the HSSD.

Basic Data Package:

- Digital Data on electronic media (clearly labeled HYDRO).
- Pressure Tide/Water Level Gauge Record.
- Progress Sketch (digital and hard copy).

Initial Data Package:

- Tide Station Report NOAA Form 77-12.
- Great Lakes Water Level Station Report NOAA Form 77-75.
- Precise Leveling Record - NOAA Form 75-183 (preferred) or Original Leveling Record – NOAA Form 76-77.
- Bench Mark Recovery Notes and Descriptions:
  - For Marine Tidal Areas - NOAA Form 76-75 or NOAA Form76-89.
  - For Great Lakes region only - NOAA Form 76-186.
  - “How to Reach” Tide Station Statement.
- Page size chart section indicating station site with north arrow (digital and hard copy).
- Sketch of bench marks, staff and gauge location. Photographs of general area of station and bench marks.

Closing or Final Data Package:

- Original Leveling Record - NOAA Form 76-77 or Precise Leveling Record - NOAA Form 75-183.
- Field Tide or Water Level Note.
- Tide Station Report - NOAA Form 77-12.
- Completed CO-OPS Evaluation Criteria for Water Level Station Documentation Check-Off List (included in Appendix 3).

5.2.3.2.5 Coast Pilot Review A Coast Pilot Review shall be completed for each project in accordance with section 3.5.6 of this manual, and submitted to NSD's Coast Pilot Branch via email to OCS.NDB@NOAA.GOV and Coast.Pilot@NOAA.GOV with a courtesy copy to the appropriate hydrographic branch. Coast Pilot Reviews shall be submitted following the completion of operations within a project area, and no later than at the time of submission of the first Descriptive Report for that project. If a survey project spans multiple years, a Coast Pilot Review shall be submitted at the conclusion of operations within the affected area each field season. An updated version of the Coast Pilot text will be included on the Project CD/DVD provided to the field unit the following season.

Note: It is critical that field units promptly submit Coast Pilot Reviews for multi-year projects at the conclusion of operations within that area so that edits can be reviewed and applied to the Coast Pilot prior to compilation of source data for the following field season.

Note: The Draft 2008 edition of the Coast Pilot Manual is included in Appendix 3.

5.2.3.3 Survey Reports

5.2.3.3.1 Descriptive Report (DR) For each survey, a Descriptive Report shall be completed in accordance with section 8.1.3 of the HSSD and Chapter 5 of this manual. The "For Descriptive Report" feature report generated in Pydro should be referenced to support information required for section D (Results and Recommendations) of the Descriptive Report. Information contained in the DAPR may be referenced in the DR to meet reporting requirements set forth in the HSSD.

5.2.3.3.2 Feature Reports Feature Reporting is handled in one of two ways, depending on which software package (either CARIS Notebook or NOAA's Pydro package) is primarily used to handle features.

5.2.3.3.2.1 Feature Reporting (Notebook) For vessels that utilize CARIS Notebook software to handle features, three CARIS Hydrographic OBject (HOB) files must be submitted to the Hydrographic Surveys Division. See 4.4.10.1 for a description of those files. A report out of Pydro is required for all Dangers to Navigation (see 4.4.4.6 for more DToN submission requirements), but no other reports are required out of Pydro for hydrographic surveys with nearshore features handled in CARIS Notebook.

5.2.3.3.2.2 Feature Reporting (Pydro) For vessels that utilize NOAA's Pydro software, a Pydro feature report must be submitted to the Hydrographic Surveys Division. Features discovered, verified, or disproved during survey operations that warrant specific detailed discussion in the Descriptive Report shall be flagged as "Report" in Pydro. This flag directs Pydro to include that feature's information when generating its "For Descriptive Report" feature report. Features within this report shall be further classified as Dangers to Navigation, AWOIS Features, Charted Features, and/or New (Uncharted) Features by applying the flagging logic described in 4.4.6.1. Any Charted Feature Removal Requests, often referred to as "anti-DTONs", shall be included in the DTON category for feature reporting purposes. The Pydro-generated feature report shall be submitted as Appendix II of the Descriptive Report.

Note: Due to the expedited processing necessary for Dangers to Navigation (including Charted Feature Removal Requests), these features have additional reporting requirements described in 4.4.4.6.

5.2.3.3.2.3 Pydro Chartlets Pydro supports creation of automated "cookie cut" chartlets for features using the OpenGL-based "HSTP Control" ChartWindow. From the ChartWindow context menu, select "Screen Capture" -> "Auto Chartlets". A subsequent dialog allows you to specify a feature tree template filter to control which items/features have chartlets generated (empty template implies use all features). Chartlets are saved in a user-specified directory in PNG format. The visible data content within each chartlet is as per the plot configuration as seen in the Pydro ChartWindow. The Auto Chartlets command can be executed multiple times to generate more than one chartlet view for any feature(s). Pydro automatically generates unique charlet names, so the same output directory can be used each time–no existing files will be overwritten. The Chartlets get a default caption in the Pydro PSS, listing the center position in decimal degrees and the width and height in meters of each chartlet image. PSS chartlet output is supported in all Pydro reporting options. The Pydro DToN report now includes a Zip archive containing the .xml and .pdf files, as well as a DToNImages folder containing all of the relevant chartlets (always included) and report images (user selectable).

5.2.3.3.2.4 Pydro Line Classification Pydro supports classification of HIPS/SIPS survey lines in compliance with HSSD. Lines can be classified in Pydro according to "mode" and "type". Line mode includes "Interferometric", "Multibeam", "Shoreline", "SideScanSonar", "SingleBeam", and "UnclassifiedMode"; multiple modes can be selected per line (not to include "UnclassifiedMode"). Line type includes "Crossline", "Development", "Mainscheme", "Other", and "UnclassifiedType"; only one type can be selected per line. Pydro line classification is accessible in the Data -> Stats -> "PVDL / In Bathy Info" and "Survey Line Info" dialogs. Any HIPS/SIPS survey lines can be brought into Pydro via Data -> Insert -> "HIPS/SIPS Survey Lines", without the added expense of inserting any associated feature or bathymetry data into the PSS. Survey line data read in this way does include the survey track and swath-bathymetry coverage limits (if any), and can therefore be used in Pydro to compute linear nautical miles (LNM) and to index full-density PVDL depth data. The Pydro information dialogs include a versatile HIPS/SIPS PVDL-filtering engine that can be used to compute LNM for any particular line mode/type classification, for any subset of project(s), vessel(s), day(s), and line(s). Each filtering category includes a choice of the use of inclusive or exclusive logic.

5.2.3.3.2.5 Pydro Surface-Points Comparisons Point and surface data comparison statistics can be compiled and reported in Pydro via Reports -> "Points/Surface Stats": - Items for localized comparison points can be those as filtered using any feature tree template, not just "Checkpoints" - Reference surface data choices include HIPS BASE/weighted grid data, in addition to PVDL binned depth data - Reference surfaces can be filtered according to precision - Comparison point data choices include HIPS BASE/weighted grids, PVDL depths, and the localized comparison item depth data - Greater control over PDF report output: grouped summary or localized details of cumulative and/or by beam or depth bin - Option for graphs and/or tabular output; graphing options for by-beam or by-depth bin and a "IHOness" pie chart of surface-minus-depth pass/fail percentages - Reference surface image output options: (filtered) bathy and (filtered) precision, as well as item/feature report images and chartlets.

5.2.3.3.3 Survey Outline Upon completion of data acquisition for a survey, a Survey Outline reflecting the actual extent of hydrography shall be submitted in accordance with the Project Instructions. Submit only the completed Survey Outline MapInfo tables via email to survey.outlines@noaa.gov and include a copy of these files in Appendix III of the Descriptive Report.

5.2.3.3.4 Request for Tides Within 24-hours of completion of data acquisition for a survey, a request for final discrete zoning (often referred to as a “smooth tides request”) shall be submitted to CO-OPS. Pydro should be used to automatically generate a zipped digital “Request for Tides” package that contains all of the survey information needed by CO-OPS. The package includes a formal memorandum requesting approved water level data, an Abstract of Times of Hydrography, and digital *.MID and *.MIF files of survey track lines. Submit the Request for Tides package via email to smooth.tides@noaa.gov, with the project number referenced in the email subject line. Once this request has been received, CO-OPS has agreed to provide field units with final water level correctors relative to the appropriate chart datum and final tidal zoning, as close to "near real-time" as possible. Final approved water levels shall be applied to all applicable survey data before data submission to HSD. If the lack of final approved water levels delays submission of a survey, please contact the appropriate HSD Operations Branch Chief or NSD Navigation Response Branch Chief . The type of tide/water level file (predicted, preliminary, or verified) applied to submitted data shall be noted in the Corrections to Echo Soundings section of the Descriptive Report. Include a copy of the digital Request for Tides package, as well as the *CORP.tab, *STNP.tab, and *LABP.tab files applied to survey data, in Appendix IV of the Descriptive Report.

5.2.3.3.5 ATON Report Information for each assigned ATON and any additional ATONs which should be reported based on the criteria defined in 3.5.3.3 of this manual shall be submitted to MCD at the completion of a survey. This ATON Report shall be a pipe delimited text file with the report fields formatted as defined below to facilitate office processing and integration into existing database systems.

- Field 1. ATON latitude (in decimal degrees to seven decimal places).
- Field 2. ATON longitude (in decimal degrees to seven decimal places).
- Field 3. Name of ATON as defined in the Light List. If the Light List does not identify this aid, a logical name should be assigned which indicates the ATON location.
- Field 4. Light List number of ATON. Leave this field blank if no Light List number exists.
- Field 5. Date of position determination.
- Field 6. Vertical precision of observations.
- Field 7. Horizontal precision of observations.
- Field 8. Standard deviation of observations.
- Field 9. ATON latitude (in degrees, minutes, and seconds to three decimal places).
- Field 10. ATON longitude (in degrees, minutes, and seconds to three decimal places).
- Field 11. ATON location description (e.g., northwest corner of pier).
- Field 12. ATON type (e.g., Special Purpose Beacon.
- Field 13. ATON shape (e.g., tower, pile, dolphin).
- Field 14. Comments (any additional information which may assist MCD in evaluating the data such as light or sound characteristics).

Note: If processing data with GPS Pathfinder Office software, an ATON report can be quickly generated using the Excel template (ATON_Submission_Template.xls) and following the corresponding instructions (ATON Submission Instructions.doc) provided in Appendix 5. ATON data may be reviewed and edited in Excel prior to creating the pipe-delimited text report.

Field units shall submit text file ATON Reports and the complete processed data record, in Shapefile format, directly to MCD via email to aton.reports@noaa.gov. Courtesy copies shall be provided to the Chief of the appropriate hydrographic branch and either Chief of OPS or Chief of NRB. A copy of the ATON Report and processed data record shall also be included in Appendix 5 (Supplemental Survey Records and Correspondence) of the DR.

5.2.3.3.6 Data Directory Size Report After data acquisition is complete for each survey, send an e-mail indicating the survey/project number, survey platform, raw MBES and/or VBES directory size, and raw SSS directory size to NGDC at hydro.info@noaa.gov with a copy to the chief of the appropriate processing branch.

5.2.3.4 Public Relations and Constituent Products

Any "one-pagers" created by the field unit that detail significant discoveries during a project should be digitally submitted to the Chief of OPS or Chief of NRB in a timely fashion for use in public relations. Likewise, feature reports created for the SHPO or Sanctuary (see 2.4.4.1 and 4.4.5) shall also be digitally submitted to the Chief of OPS or Chief of NRB.

When submitting data to AHB or PHB, include with the digital survey deliverables any final MapInfo tables and workspaces for plots used to create, "one-pagers" (in *.pdf format) for public relations, constituents, navigation managers. Likewise, include any data used to create the feature report for the SHPO or Sanctuary contact.

Note: Prior to releasing any preliminary survey data to parties outside of OCS, personnel shall obtain approval from the Chief-of-Party and notify the Chief of OPS or Chief of NRB. All preliminary data products shall be annotated with the following information: Date of Survey: Soundings in (feet, fathoms or meters) at MLLW corrected using (predicted, preliminary observed, or verified observed) tides. The optimum and most accurate tide reducers are derived from verified observed tides and include final tidal zoning schemes. Data reflect the state of the sea floor in existence on the day and at the time the survey was conducted. The survey and the chart have not been updated for inclusion of the latest Local Notice to Mariners. Preliminary data subject to office review. Not for use in navigation.

5.2.4 NODC Files

Each time a sound speed profile is processed using Velocwin, an archive file will be automatically generated in the proper format for submission to the National Oceanographic Data Center (NODC). At the conclusion of a project, these archive files shall be submitted to HSTP. All NODC files associated with the project should be zipped into a single file and transmitted as an email attachment to NODC.Submissions@noaa.gov. The files will be checked by HSTP and forwarded to the NODC for inclusion in the World Ocean Database.

Be certain to submit the archive files created by Velocwin, and not the historical NODC files used by Velocwin as a quality control tool. The NODC files to be submitted can be identified by their naming convention. The file names will indicate the cast date and time and have an extension ending in "a" for CTD casts and "d" for sound speed versus depth profilers, as shown below.

Filename examples - YYDDDHHMM.ssa or YYDDDHHMM.ssd, where:

YY = 2-digit year

DDD = day-of-year

HH = hour of day (UTC)

MM= minutes of the hour

ss = ship code

Note: NODC files should not be included in the survey data submitted to either AHB or PHB.

5.2.5 Transmittal Procedures

Final survey data submitted to either AHB or PHB should be complete and not require supplemental data from other surveys in the project. All survey data submitted shall be packaged to safeguard against loss or damage and be accompanied by a hard copy transmittal letter (NOAA Form 61-29, Letter Transmitting Data). Additionally, a digital copy of the transmittal letter(s) should be submitted via e-mail to the cognizant hydrographic branch at the time the data is transferred using either LTDSubmission.AHB@noaa.gov or LTDSubmission.PHB@noaa.gov as appropriate. If shipping more than one package, a separate transmittal should be used for each package. The transmittal letter shall indicate the contents of the package and list all digital media being submitted (e.g., tapes, portable hard drives, CD, DVD) with a detailed catalog of the data contained on each and the file name of the digital directory listing created in accordance with 5.2.1 of this manual. If additional pages are needed for the transmittal letter, the project number and survey registry number shall be included on each page. Transmittal letters can be created in Pydro through the Reports > NOAA Forms menu, and should be signed digitally.

Data shall be shipped to the appropriate hydrographic branch at one of the following addresses:

NOAA, National Ocean Service

Atlantic Hydrographic Branch, N/CS33

439 West York Street

Norfolk, Virginia 23510-1114

NOAA, National Ocean Service

Pacific Hydrographic Branch, N/CS34

BIN C15700, Bldg. 3

7600 Sand Point Way N.E.

Seattle, Washington 98115-0700

Chapter 6

Acronyms

ACSM	American Conference on Surveying and Mapping
AHB	Atlantic Hydrographic Branch
ARP	Antenna Reference Point
AWOIS	Automated Wreck and Obstruction Information System
BASE	Bathymetry Associated with Statistical Error
BS	Bottom Sample
CEF	Chart Evaluation File
CFF	Cartographic Feature File
CGTP	Cartographic and Geospatial Technology Programs
CO	Commanding Officer
CO-OPS	Center for Operational Oceanographic Products and Services
CM	Center of Motion
CSDL	Coast Survey Development Laboratory
CTD	Conductivity Temperature Depth
DAPR	Data Acquisition and Processing Report
DGPS	Differential Global Positioning System
DIG	Digilink data file format
DPAS	Data Processing and Analysis System
DTM	Digital Terrain Model
DXF	Drawing eXchange File format, a text representation of the binary
DWG	format
EED	Electronic Engineering Division
ENC	Electronic Navigational Chart

FOD	Field Operations Division
FOO	Field Operations Officer
FPM	Field Procedures Manual
FTP	File Transfer Protocol
GAMS	GPS Azimuth Measurement Subsystem
GEODAS	Geophysical Data System
HDCS	Hydrographic Data Cleaning System
HDOP	Horizontal Dilution of Precision HorCon Horizontal Control
HSD	Hydrographic Surveys Division
HSRR	Hydrographic Systems Readiness Review
HSSD	NOS Hydrographic Surveys Specifications and Deliverables
HSTP	Hydrographic Systems and Technology Program
HVF	Hydrographic Vessel File
IHO	International Hydrographic Organization
IMU	Inertial Measurement Unit
INS	Inertial Navigation Systems
MBES	Multibeam Echosounder
MCD	Marine Charting Division
MOC-A	Marine Operations Center - Atlantic
MOC-P	Marine Operations Center - Pacific
NAD83	North American Datum of 1983
NALL	Navigable Area Limit Line
NESDIS	National Environmental Satellite, Data, and Information
NGA	National Geospatial Intelligence Agency, formerly NIMA & DMA
NGDC	National Geophysical Data Center
NGS	National Geodetic Survey
NMEA	National Marine Electronics Association
NIMA	National Imagery and Mapping Agency
NMAO	NOAA Marine and Aviation Operations
NODC	National Oceanographic Data Center
NOS	National Ocean Service
NRB	Navigation Response Branch
NRT	Navigation Response Team

NSD	Navigation Services Division
OCS	Office of Coast Survey
OS	Operating System
OWTT	One Way Travel Time
PDOP	Positional Dilution of Precision
PHB	Pacific Hydrographic Branch
PI	Project Instructions
POD	Plan of the Day
POS/MV	Position and Orientation System, Motor Vessel
PVDL	Project Vessel Day Line
RDT	Rotating Directional Transmission
SDF	Sonar Data File
SHPO	State Historic Preservation Officer
SSS	Side Scan Sonar
SWMB	Shallow Water Multibeam
TCARI	Tidal Constituent and Residual Interpolation
TPE	Total Propagated Error
TPU	Total Propagated Uncertainty
TVG	Time-Varied Gain
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
UTM	Universal Transverse Mercator
VBES	Vertical Beam Echosounder
VerCon	Vertical Control
WAAS	Wide Area Augmentation System
XTF	Extended Triton Format

Chapter 7

Glossary

7.1 A

ABANDONED

An adjective referring to a man-made facility no longer being used for its original purpose. The term may be used with a symbol, e.g., beside an airport symbol, or with a place name, e.g., Elma (Abandoned).

ABSOLUTE ERROR

Absolute deviation (the value taken without regard to its sign) from the corresponding true value.

ACCRETION

The gradual building up of land over a long period of time, solely by the action of the forces of nature, on a beach by deposition of water or airborne material. Artificial accretion is a similar build-up of land by reason of an act of man. Also called aggradations.

ACCURACY

Closeness of a measured or estimated value to a standard or accepted value of a particular quantity.

ACROSS TRACK

The dimension of the seabed or data record in a direction lateral to the track of the survey vessel or towfish. This is the opposite of the along-track dimension. These two terms are used to describe sonar phenomena and dimensional corrections.

ADJUSTED POSITION

An adjusted geographic position of a point on the earth in which discrepancies arising from errors in the observational data are removed; a fixed position.

ADR GAUGE

Analog to Digital Recording tide gauge. A float or pressure actuated tide gauge that records the heights at regular time intervals in digital format.

ADRIFT

Afloat or unattached to shore or bottom.

AERIAL SURVEY

A survey using aerial photographs as part of the surveying operation; also, the taking of aerial photographs for surveying purposes.

AEROTRIANGULATION

Triangulation for the extension of horizontal and (or) vertical control accomplished by means of aerial photographs.

AFLOAT

Floating, as opposed to being aground.

AGROUND

Touching, resting, or lodged on the seafloor in shallow water. The opposite is afloat.

AID TO NAVIGATION

A device external to a craft, designed to assist in determination of position of the craft, a safe course, or to warn of dangers or obstructions. The expression “Aid to Navigation” should not be confused with “Navigational Aid”, a broad expression covering any instrument, device, chart, method, etc., intended to assist in the navigation of a craft. See Navigational Aid.

ALMANAC

The almanac is a set of parameters used by a Global Positioning System (GPS) receiver to predict the approximate location of a navigation satellite and the expected offset of the satellite’s clock. Each GPS satellite contains and transmits the almanac data for the entire satellite network. See Ephemeris.

ALONG TRACK

The dimension of the seabed or data record in a direction parallel to the track of the towfish (transverse). This is the opposite of the across track dimension. These two terms are used to describe sonar phenomena and dimensional corrections.

ALTITUDE

The height of a towfish above the seabed, typically measured in feet or meters. Proper towfish altitude is important for acceptable seabed backscattering and to avoid seabed collisions. An excessively low altitude will reduce the range at which effective backscattering is produced. Excessively high altitudes can leave uninsonified seabed as well as prevent accurate slant range correction.

AMBIENT NOISE

Acoustic signals, sensed by the sonar system, emanating from a variety of sources in the underwater environment. Ambient noise visible in sonar data can result from propeller cavitation, engine noise, and biological sources. Other sources are environmental, such as wind, waves, and rain.

ANCHORAGE An area where a ship anchors or may anchor, either because of suitability or designation. A suitable place for anchoring is sheltered from wind and sea, does not interfere with harbor traffic, and has a sea bottom that gives good holding to anchors. The anchorage space allotted to a vessel should include a circle with a radius equal to the combined length of anchor chain and ship.

ANCHORAGE CHART

A nautical chart showing prescribed or recommended anchorages. Such a chart may be a harbor chart overprinted with a series of circles, each indicating an individual anchorage.

ANGLE OF INCIDENCE

The angle that a straight line acoustic pulse meeting a surface makes with a normal to the surface. The angle of incidence is important in sonar backscattering. For instance, if the sonar altitude is too low, at long ranges the angle of incidence with the seabed becomes high. Much of the incident energy is not returned to the transducer. Further, if the seabed angles up at the outer ranges, the angle of incidence becomes lower and more energy will be returned, making a notable anomaly in the data.

APPARENT SHORELINE

The seaward limits of marine vegetation, such as mangrove, marsh grass, or trees in water that would reasonably appear to the mariner from a distance to be the fast shoreline. The seaward limits of kelp, low grass in water, and other low-lying vegetation normally do not constitute an apparent shoreline.

A line drawn on the chart in lieu of the mean high water line or the mean water level line in areas where either may be obscured by marsh, mangrove, cypress, or other type of marine vegetation. This line represents the intersection of the appropriate vertical datum with the outer limits of vegetation and appears to the navigator as shoreline.

APPROXIMATE CONTOUR

A contour substituted for a normal contour whenever there is a question as to its reliability (reliability is defined as being accurate within one-half the contour interval).

APPROXIMATE POSITION

A charting term meaning a position that is considered to be within 100 ft of its correct geographic location but less than third order or equivalent specification. Usually shown by the abbreviation “P.A.” Alternative form: Position Approximate.

ARCHIVE MEDIA

Either magnetic media or compact discs. Magnetic media includes DAT DDS 4 mm tapes, DLT (digital linear tape), 8 mm Exabyte tape, and Ultrium LTO (linear optical tape). Compact discs include both CDs and DVDs.

ARTIFACT Bias-related error. See Bias, Systematic Error.

AREA AND DEPTH SHEETS

A plotted representation of information acquired during a wire-drag survey. The results of the survey are depicted as polygons representing the areas of coverage by the wire drag apparatus. Only the deepest of these is shown. Each area is annotated with the corrected depth of the wire at the time of operations. The sheets may also include information identifying specific depths at locations of hangs or groundings.

AREA CHARTS

NOS charts which are versions of conventional nautical charts overprinted with additional small-craft information, and published in the pocket-fold format.

AREA FEATURE

An area feature is an item such as a fish haven, a disposal area, or a prohibited or quarantine area which consists of a region with defined boundaries.

ARGO

A medium-range electronic positioning system once used for horizontal control purposes during hydrographic surveys.

ATOLL

A coral island or islands, consisting of a belt of coral reef surrounding a central lagoon. A ring-shaped coral reef which has closely spaced islands or islets on it enclosing a deeper central area or lagoon. The diameter may vary from less than a mile to 80 miles or more.

ATTENUATION

The process of weakening or reducing the amplitude of a sonar signal. It is caused by numerous factors, including material dispersion, beam spreading, and absorption. The attenuation of a sonar signal makes its detection more difficult. Reflected signals from far ranges are sometimes attenuated to such a degree that system noise in the sonar receiver electronics can be a problem.

AUTOMATED WRECK AND OBSTRUCTION INFORMATION SYSTEM (AWOIS)

A database containing information about wrecks and obstructions located in areas charted by NOAA. The primary purpose of this system is to support operational hydrography, although it is available online to the general public.

AUV

Acronym for Autonomous Underwater Vehicle, an unmanned underwater vehicle that conducts operations from pre-programmed instructions without being tethered or otherwise attached to a support vessel. See ROV.

AWASH

Situated so that the top is intermittently washed by waves or tidal action. The term applies both to fixed objects such as rocks, and to floating objects with their tops flush with or slightly above the surface of the water.

AWOIS

See Automated Wreck and Obstruction Information System.

AZIMUTH

A horizontal angle reckoned clockwise from the meridian. In the basic control surveys of the U. S., azimuths have been historically reckoned from south. In 1986, when the NGS began publishing geodetic data on the North American Datum of 1983 (NAD83), the measurement of azimuths was referenced from the north for basic control surveys.

7.2 B

BACKSCATTER

The deflection of acoustic energy in a scattering process, commonly used to describe the return of energy from the seabed to the receiver of a sonar. See Scattering.

BACKSHORE

That part of a beach which is usually dry, being reached only by the highest tides and, by extension, a narrow strip of relatively flat coast bordering the sea.

BANK

1. An elevation of the sea floor located on a continental or an island shelf and over which the depth of water is relatively shallow but sufficient for safe surface navigation. Reefs or shoals, dangerous to surface navigation, may rise above the general depths of a bank. 2. A shallow area consisting of shifting forms of silt, sand, mud, and gravel; in this case it is only used with a qualifying word, such as “sandbank” or “gravelbank.” 3. The edge of a cut or fill. The edge of a waterway or channel.

BAR

A ridge or mound of sand, gravel, or other unconsolidated material below the high water level, especially at the mouth of a river or estuary, or lying a short distance from and usually parallel to the beach, and which may obstruct navigation.

BAR CHECK

A method of field-calibrating sounding equipment used in a hydrographic survey by suspending a bar or disc beneath the echosounder transducer at various depths. Echoes from this surface are compared to the actual known depth of the bar.

BARE

Extending above the datum of mean high water. In nautical charting, used to qualify rocks which extend more than one foot above mean high water on the Atlantic and Gulf Coasts, and extending more than two feet above mean high water on the Pacific coast.

BARRIER REEF

A coral reef fronting, but at some distance from, the shore and separated from the shore by a lagoon.

BAR SCALE

A line or series of lines on a chart or map subdivided and labeled with the distances represented on the chart or map. Also called Graphic Scale.

BASE LINE

A surveyed line established with more than usual care to which surveys are referred for coordination and correlation. Base lines are established for specific purposes; the pertinent ones are defined below: 1. The side of one of a series of connected triangles, the length of which is measured to a prescribed standard of accuracy and from which the lengths of the sides of the other triangles were obtained by computation. Base lines in triangulation are classified according to the character of the work they were intended to control; the instruments and methods used in their measurement assure that the prescribed standards of accuracy were met. 2. The reference used to position limits of the territorial sea and the contiguous zone. The U. S. base line is determined from the mean lower low water line. The United Nations Conference on the Law of the Sea defined the low water line along a coast, as shown on large-scale charts of the coastal State (country), to be the base line for determining the limit of the territorial sea.

BASE (BATHYMETRY ASSOCIATED WITH STATISTICAL ERROR) SURFACE

A CARIS software generated seafloor model, created by one or more different algorithms, that contains depth and uncertainty at each model node. It can also contain one or more auxiliary information layers, including standard deviation of soundings, sounding density, shoal depth, source identification, hypothesis count, hypothesis strength, and others, in addition to the basic bathymetric layer. Content of the auxiliary layers depends on the algorithm used to construct the BASE surface.

BASIC SURVEY (Hydrographic)

A comprehensive and complete hydrographic survey adequate to supersede all prior hydrographic surveys covering the common area, and to verify or discredit/disprove the existence of all charted or reported features.

BATHYMETRIC MAP

A topographic map of the ocean floor, or the bed of a lake. Generally, bathymetric maps show depths by contour lines and gradient tints. Sometimes referred to as a bathymetric chart.

BATHYMETRY

The measurement of depths of water in oceans, seas and lakes. Also the information derived from such measurements.

BAUD

A unit of speed for the transfer of data. The speed in baud is the number of discrete conditions or events per second.

BAY

An indentation of the coast; an embayment; a subordinate adjunct to a larger body of water; a body of water between and inside of two headlands. According to the Geneva Convention, a well-marked indentation whose penetration is in such proportion to the width of its mouth as to contain landlocked waters and constitute more than a mere curvature of the coast. The area of such an indentation must be as large as, or larger than, the semicircle whose diameter is a line drawn across the mouth of the indentation. (The specifications are contained in Article 7 of the Convention on the Territorial Sea and the Contiguous Zone.)

BAYOU

A small sluggish stream or estuarine creek, with a slow or imperceptible current in coastal swamps or river deltas. Sometimes called Slough.

BEACH

1. The area between the extreme high-water and extreme low-water lines extending from such water lines inland to a marked change in physiographic form or material or to the line of permanent vegetation. 2. That area of the shore upon which the waves break and over which shore debris accumulates. A beach includes backshore and foreshore. 3. To intentionally run a craft ashore, as a landing ship.

BEACON 1. A fixed aid to navigation. 2. Anything serving as a signal or conspicuous indication, either for guidance or warning.

BEAM COMPASS A drafting instrument for drawing circles with a long radius. The point and the pen, or pencil tip, are separate units, mounted to slide and clamp on a long bar or “beam” so that the distance between them is equal to the desired radius.

BEAM FORMING

The process of shaping an acoustic beam through the control of the geometry of the transducer array. As the shape of the acoustic beam is crucial in imaging sonar systems, careful beam forming is important. The size, shape, and arrangement of groups of transducer elements help form the beam.

BEAM SPREADING

The divergence of a sonar beam as a direct function of angle and range. Beam spreading causes a loss of resolution in the far ranges; however, where the beam is wider the system ensonifies more of the environment per ping. Beam spreading also causes adjacent beams in the far ranges to overlap, which may be advantageous in some side scan sonar operations.

BEAM WIDTH

The angular measure of the transverse section of a beam (usually in the main lobe) lying within directions corresponding to specified values of field strength (usually -3 db) relative to the maximum.

BEARING

The horizontal direction of a line of sight between two objects on the surface of the earth.

BED

The ground upon which a body of water rests. The term is usually used with a modifier to indicate the type of water body, as river bed or sea bed.

BELL BUOY

A steel float surmounted by a short skeleton tower in which the bell is fixed. Most bell buoys are sounded by the motion of the buoy in the sea. In a few buoys, the bells are struck by compressed gas or electrically operated hammers.

BENCH MARK

A fixed physical object containing a marked point of known elevation with respect to a datum used as a reference level for tidal observations or as a control point for leveling. With the advent of GPS an increasing number of bench marks are also used for spatial reference with regard to horizontal control.

BENCH MARK (Tidal)

A fixed physical object or mark used as reference for a horizontal or vertical datum. A tidal bench mark is one near a tide station to which the tide staff and tidal datums are referred. A primary bench mark is the principal mark of a group of tidal bench marks to which the tide staff and tidal datums are referred. The standard tidal bench mark of the National Ocean Service is a brass, bronze, or aluminum alloy disk 3-1/2 inches in diameter containing the inscription NATIONAL OCEAN SERVICE, together with other individual identifying information. A geodetic bench mark identifies a surveyed point in the National Spatial Reference System. Bench mark disks of either type may, on occasion, serve simultaneously to reference both tidal and geodetic datums.

BERTH

A place in which a ship is, or can be, moored.

BIAS

The distortion of a result through negligence of a factor usually introducing a systematic error of unchanging magnitude and sign throughout a given series of observations.

BIFURCATION BUOY

A buoy which, when viewed from a vessel approaching from the open sea or in the same direction as the main stream of flood current, or in the direction established by appropriate authority, indicates the place at which a channel divides in two. See also Junction Buoy.

BIGHT

A bend or curve; a bend in a coast forming an open bay; a small open bay formed by an indentation in the coast; a minor feature which affords little protection for vessels.

BIN (BIN, BINNED, BINNING)

One process used to thin dense hydrographic data where the shoalest sounding is selected in an N-by-N m box, called a bin. Another method of data decimation is called “gridding” which considers points in proximity to a grid node – usually a radial distance.

BLUE TINT CURVE

A nautical charting term describing the use of a blue tint in the water areas associated with a depth curve or contour. The blue tint curve is considered the danger curve for vessels expected to use that particular chart.

BLUNDER

A mistake. A blunder is not an error, although a small blunder may remain undetected in a series of observations and have the effect of an error in determining the result. Examples of blunders are: reading a horizontal circle incorrectly by an even degree; neglecting to record the tape length in a measured traverse; and reversing numerals in recording an observation.

BOAT HOUSE

A building at or near a shore for the storage of boats.

BOAT SHEET

The work sheet used by a hydrographer in the field for plotting the details of a hydrographic survey as it progresses. It may include projection lines, control stations, shoreline, and proposed sounding lines, and corresponds to what was termed a “diagram,” “sounding sheet,” or a “working sheet” in early project instructions.

BOOM

A floating barrier used to protect a river or harbor mouth or to create a harbored area for storage purposes. See also log boom.

BORE

A very rapid rise of the tide in which the advancing water presents an abrupt front of considerable height. Bores generally occur in shallow estuaries where the range of tide is large.

BOTTOM CHARACTERISTICS

Designations used on smooth sheets and nautical/navigational charts to indicate the size, consistency, color, and classification of bottom sediments. Thus, “soft gray sand, shells, pebbles” is designated “sft gy S Sh P.” The expressions “bottom characteristics” and “bottom sample” are not to be used interchangeably.

BOTTOM SAMPLE

Samples of the ocean bottom obtained by means of a mechanical device designed to collect relatively small-sized material. The actual bottom materials/sediments obtained in the “sampling” procedure.

BOULDER

A more or less rounded rock, larger than a cobblestone and as much as 10 ft or more in diameter.

BOUNDING MERIDIAN

A meridian which is coincident with a part of the neat line of a map or chart.

BOWDITCH

See Publication No. 9.

BREAKER

A wave that has become so steep that the crest of the wave topples forward, moving faster than the main body of the wave.

BREAKWATER

A structure protecting a shore area, harbor, anchorage, or basin from waves. A floating breakwater is a contrivance consisting of floating materials connected by mooring chains or cables attached to anchors or stone blocks in such a manner as to form a basin within which vessels may be protected from the violence of waves. A breakwater may be attached to or separated from the shore. Part of the coast line from which maritime zones are measured.

BRIDGE

A structure designed to carry traffic over a depression or other obstruction. The term refers to a lawful bridge over navigable waters of the United States, including approaches, fenders, and appurtenances thereto, which is used and operated for the purpose of carrying railroad traffic, or both railroad and highway traffic, or if a State, county or municipality, or other political subdivision is the owner or joint owner thereof, which is used and operated for the purpose of carrying highway traffic.

BRIDGE CLEARANCE

Minimum vertical or horizontal space available for passage. Vertical clearances are referenced to the plane of high water adopted for charting.

BROADCAST NOTICE TO MARINERS

A radio transmission by the U. S. Coast Guard to provide important marine information.

BROOK

A stream of less length and volume than a creek, as used locally in the Northeast. Generally, one of the smallest branches or ultimate ramifications of a drainage system.

BSB

Digital format of navigation charts (RNC). The BSB format was developed by Maptech under license by NOAA to produce digital images of paper charts. File extensions are *.bsb and *.kap.

BULKHEAD

1. A structure built to retain or prevent sliding of the land. A secondary purpose is to protect the upland against damage from wave action. Bulkheads are frequently filled behind, thereby increasing the utility of the adjacent land.

2. A nautical term used aboard ship. It is analogous to a “wall” in a building.

BUOY

A floating object, other than a lightship, moored or anchored to the bottom to serve as an aid to navigation. Buoys may be classified according to shape, color, or special purpose.

BUOYAGE

A system of buoys. One in which the buoys are assigned shape, color, and number distinction in accordance with location relative to the nearest obstruction is called a cardinal system. One in which buoys are assigned shape, color, and number distinction as a means of indicating navigable waters is called a lateral system.

7.3 C

CABLE

A unit of distance originally equal to the length of a ship’s anchor cable, but now generally considered to be about 600 feet. In the British Navy it is 608 feet, or exactly one-tenth of a nautical mile. In the U.S. Navy it is 720 feet but is infrequently used.

CADASTRAL SURVEY

A cadastral survey is a land survey that defines boundaries, property lines, and other measurements pertaining to an official register of ownership, known as a cadastre. A cadastral survey helps determine the expanse and value of real property for resale and taxation.

CAIRN

A mound of rough stones or concrete, usually conical or pyramidal, raised as a landmark or to designate a point of importance in surveying.

CAISSON

A steel structure used for closing the entrance of locks and wet and dry docks. Also a type of steel cylindrical foundation used for some lighthouses.

CANAL

An artificial waterway for navigation. A long narrow arm of the sea extending inland between islands or between islands and the mainland. A sluggish coastal stream, as used locally on the Atlantic coast of the U.S.

CANOE CHARTS

Nautical charts of the Minnesota-Ontario Border Lakes. Most Canoe Charts do not show hydrography. They are intended to portray the general shape and size of these lakes and to provide information of interest to campers and boaters.

CANYON

On the sea floor, a relatively narrow, deep depression with steep sides, the bottom of which generally has a continuous slope.

CAPE

A relatively extensive land area jutting seaward from a continent or large island, which prominently marks a change in or interrupts notably the coastal trend.

CARDINAL POINT

Any of the four principal directions: north, east, south, or west. Directions midway between cardinal points are called inter-cardinal points.

CARDINAL SYSTEM

A buoyage system generally used to indicate dangers where the coast is flanked by numerous islands, rocks, and shoals, as well as to indicate dangers in the open sea. In this system the bearing (true) of the mark from the danger is indicated to the nearest cardinal point. The buoys are assigned shape, color, and number distinction in accordance with location relative to the nearest obstruction. The cardinal points delineate the sectors for buoy location.

CARIS FIELD SHEET

See field sheet.

CARRIER PHASE

The fraction of a cycle often expressed in degrees, where 360 degrees equals a complete cycle. Carrier phase can also mean the number of complete cycles plus a fractional cycle. A survey-grade GPS receiver can lock-on to a satellite and count the number of whole cycles of the carrier frequency, measuring the cumulative phase of the signal. This is often referred to as integrated Doppler.

CARTESIAN COORDINATES

Named after René Descartes, a French philosopher and mathematician. A pair of numbers (x, y), defining the position of a point in a two-dimensional space by its perpendicular projection onto two axes which are at right angle to each other.

CARTOGRAPHER

One who practices Cartography, particularly a member of a profession regularly concerned with any stage in the evaluation, compilation, design, or drafting of a map or chart.

CARTOGRAPHIC CODE

A proprietary system of numeric identifiers used to index a variety of cartographic symbols used in the compilation of smooth sheets. The codes may also appear embedded in various digital records containing information on sounding and features observed during a hydrographic survey.

CARTOGRAPHIC FEATURE

A term applied to the natural or cultural items shown on a map or chart. The three main categories are point feature, line feature, and area feature.

CARTOGRAPHIC INTERPRETATION

The process of interpreting data for a particular purpose, such as nautical charting. Selected features are retained and highlighted in the data, and other features may be neglected or shifted, depending on the purpose of the product.

CARTOGRAPHY

The art, science, and technology of making maps, together with their study as scientific documents and works of art. In this context maps may be regarded as including all types of maps, plans, charts, and sections, three-dimensional models, and globes representing the Earth or any celestial body at any scale.

CASCADE

A fall of water over steeply sloping rocks, usually comparatively small or one of a series.

CATENARY

The curve(s) assumed by a tow cable moving through the water, typically induced by the forces of water drag on the cable. The catenary is a significant factor in computing the horizontal distance to a towfish from the towing block. Towfish drag coefficients, cable weight, and drag and length-of-cable-out determine the shape of cable catenaries. The sweep wire as part of a wire-drag rig also assumes the catenary shape when being towed.

CATARACT

A waterfall, usually larger than a cascade, over a precipice.

CAUSEWAY

A raised way, as for a road across wet ground or water.

CAY

A low, flat island of sand, coral, etc., awash or drying at low water; a term originally applied to the coral islets around the coast and islands of the Caribbean Sea. When spelled key, refers to a low, insular bank of sand, coral, etc., (e.g., one of the islets off the southern coast of Florida).

C-COAST

(Coastal Cartographic Object Attribute Source Table) The NGS's attribution scheme which was developed to conform the attribution of various sources of shoreline data into one attribution catalog. C-COAST is not a recognized standard but was influenced by the IHO's S-57 Object-Attribute standard so that the data would be more accurately translated into S-57. C-COAST is used to attribute GC's which are provided to field units conducting hydrography.

CENTERLINE CONTROLLING DEPTH

The controlling depth of a waterway which applies only to the center of the waterway; it is usually the result of a reconnaissance-type survey consisting of only a few lines of soundings which do not provide adequate coverage to determine the controlling depth of the entire waterway.

CENTRAL MERIDIAN

1. The line of longitude at the center of a projection. Generally, the basis for constructing the projection. 2. The longitude of origin at the center of each 6-degree zone of the Universal Transverse Mercator (UTM) grid. The central meridian is arbitrarily numbered 500,000 and called a false easting. 3. In the State Plane Coordinate System, the meridian is used as the y-axis for computing projection tables for a state coordinate system. The central meridian of the system usually passes close to the center of the figure of the area or zone for which the tables are computed.

CHAIN

1. A group of associated stations of a radio navigation system. A LORAN-C chain consists of a master station and 2 - 4 secondary stations. 2. The unit of length prescribed by law for the survey of the public lands of the United States. The chain is equivalent to 66 ft or 4 rods, poles, or perches. Ten square chains equal one acre.

CHANNEL

1. A natural or artificial waterway of perceptible extent which either periodically or continuously contains moving water, or which forms a connecting link between two bodies of water. 2. The part of a body of water deep enough to be used for navigation through an area otherwise too shallow for navigation. 3. The deepest portion of a stream, bay, or strait through which the main volume or current of water flows. 4. A band of radio frequencies with which a radio station must maintain its modulated carrier frequency to prevent interference with stations on adjacent channels. 5. One of two or more signals in a multi-signal sonar system; the area on the display or sonar record where data from this signal is shown. Modern instrumented sonar systems may utilize separate channels for many kinds of data such as: port and starboard side scan, sub bottom, towbody heading, depth, conductivity, temperature, and magnetometry.

CHAPP

Chart History And Plotting Parameter file containing identifying information concerning each KAPP in the database.

CHART (Nautical)

A special purpose map specifically designed to meet the requirements of, and to promote, safe navigation. Included on most nautical/navigational charts are: depths of water, characteristics of the bottom, elevations of selected topographic features, general configuration of the coast or shoreline, dangers, obstructions and aids to navigation, limited water level data, and information about magnetic variation in the charted area.

CHART (Navigational)

Similar to a Nautical Chart but different in that it consists of a database of chart features and their attributes which is used in an ECDIS to construct and query a chart-like display. The ENC data is written in an exchange standard of the IHO designated S-57. See ECDIS and ENC .

CHART AGENT

Business establishments that are under contract with NOAA and receive discounts for resale of nautical and aeronautical navigational charts and related publications to the general public at retail prices stipulated by the agency.

CHART DATUM

The datum to which soundings on a chart are referred. It is usually taken to correspond to a low-water elevation. Since 1989, chart datum has been Mean Lower Low Water (MLLW) for all marine waters of the United States, its territories, the Commonwealth of Puerto Rico, and the Trust Territory of the Pacific Islands. Depths on charts of inland waters may be referenced to a local datum. CHARTED DEPTH The vertical distance from the chart datum to the seafloor, lake or river bottom.

CHART EVALUATION FILE (CEF)

An ESRI Shapefile containing 2-D polygons intended for overlay on an included NOAA nautical chart (or set of charts) within a Geographic Information System. The CEF is created in association with a photogrammetric shoreline mapping or change analysis project, in order to document navigational hazards, landmarks, fixed aids, and coastline features portrayed on NOAA nautical chart products whose existence or geographic position can not be confirmed photogrammetrically, or whose size, shape, orientation or position appear to have changed significantly from the current chart portrayal.

CHART EVALUATION SURVEY (CES)

A product of NOAA's Chart Evaluations Surveys (CES) program intended to: • Resolve all deficiencies reported or discovered. A deficiency is defined as charted information that can be made more complete through field examination, or information which should be charted but is not. • Evaluate the adequacy/accuracy of hydrographic information on existing charts. • Verify or revise information published in the appropriate Coast Pilot. • Conduct user evaluation and public relations efforts to provide an awareness of agency products and obtain user input.

CHART HISTORY

A record of the original compilation and subsequent corrections of every chart published by NOAA. The chart history preserves, in compact form, every detail and authority used on the chart, together with the date when a correction was applied. Also called History Sheet.

CHART LETTER

A designation applied to source documents received by the agency for use in revising nautical/navigational charts. They may originate from within or outside the agency. The physical size of the document determines whether it is registered as a chart letter or a blueprint. Each document is registered within the source data system with a unique identifier number.

CHART MAINTENANCE PRINT

An annotated copy of a shoreline map, a revision print, a revised topographic map, a photogrammetrically revised chart, or other graphic generated photogrammetrically, showing the differences between that document and the latest edition of the largest-scale nautical chart of the area.

CHART PROJECTION

See Map Projection, Projection .

CHARTLET

1. A small chart or portion of a chart scaled and used to display survey data. 2. A corrected reproduction of a small area of a nautical chart which is pasted to the chart for which it is issued. These chartlets are disseminated in Notices to Mariners when the corrections are too numerous, and such detail is not feasible in printed form.

CHIEF-OF-PARTY

The Commanding Officer of a NOAA ship or the Officer-in-Charge or Team Leader of a NOAA field party.

CHIMNEY

A relatively small, upright structure projecting above a building for the conveyance of smoke. Sometimes denoted on charts as a landmark.

CHIRP

A type of sonar technology utilizing a separate projector and hydrophone, in which the projector transmits digitally produced, linear, swept FM pulses resulting in an increased system bandwidth. Because these systems are multi-frequency, greater bandwidth, rather than the pulse length, results in higher theoretical range resolution. Chirp technology has been successfully used in sub bottom profilers, and is being developed for long-range side scan applications.

CLIFF

Land arising abruptly for a considerable distance above water or surrounding land, characterized by a high, extremely steep rock face, approaching a vertical incline.

CLOSING LINE

The line dividing inland waters and the marginal sea across the entrance of a true bay. COAST The zone of land of indefinite width (may be several miles) that extends inland from the shore to the first major change in terrain features.

COAST CHARTS

Nautical charts published at scales from 1:50,001 to 1:150,000 intended for nearshore navigation inside outlying reefs and shoals, in entering or leaving bays and harbors of considerable size, and in navigating the larger inland waterways.

COAST LINE (two words)

The line of contact between land and sea. The low water datum for purposes of the Submerged Lands Act (Public Law 31). According to Public Law 31, the line of ordinary low water along that portion of the coast which is in direct contact with the open sea and the line marking the seaward limit of inland waters. Coast line has significance for both domestic and international law (in which it is termed the "baseline"), and is subject to precise definitions. Special problems arise when offshore rocks, islands, or other bodies exist, and the line may have to be drawn to seaward of such bodies. See also Coastline (one word).

COAST PILOT

A descriptive book for the use of mariners, containing detailed information on the coastal waters, harbor facilities, etc., of an area. Such books are prepared by NOAA for waters of the United States and it possessions and are intended to supplement the nautical chart.

COASTAL CONFLUENCE ZONE

A coastal area of the U.S. which has an outer boundary of 50 nautical miles from shore or the 100 fathom curve, whichever is farther, and an inner boundary of the shore line or the outer boundary of the harbor entrance, whichever is farther.

COASTAL WATERS

1. The U.S. waters of the Great Lakes 2. The territorial seas of the U.S. 3. Those waters directly connected to the Great Lakes and territorial seas (i.e., bays, sounds, harbors, rivers, inlets, etc.) where any entrance exceeds 2 nautical miles between opposite shorelines to the first point where the largest distance between shorelines narrows to 2 miles as shown on the current edition of the appropriate agency chart used for navigation.

COASTLINE

(one word) The line of contact between land and sea. In OCS, the term is considered synonymous with shoreline. The use of this term is discouraged. See also Coast Line (two words).

COBBLE

Rounded rocks ranging in diameter from approximately 64 - 256 mm.

COLREGS

Acronym for International Regulations for Preventing Collisions at Sea. Lines of demarcation delineating those waters upon which mariners must comply with the International Regulations for Preventing Collisions at Sea, 1972 (72 COLREGS) and those waters upon which mariners must comply with the Navigation Rules for Harbors, Rivers, and Inland Waters (Inland Rules). The waters outside the lines are COLREG waters. For specifics concerning COLREGS Demarcation Lines, see U.S. Code of Federal Regulations, Title 33, Navigation and Navigable Waters; Part 82, COLREGS Demarcation Lines. See Inland Rules of the Road.

COMBINED UNCERTAINTY

In the context of the uncertainty of a finalized bathymetry grid, the greater of the standard deviation (scaled to 95%) and the grid uncertainty, which is derived from the total propagated error of the soundings that contributed to that node. COMPASS MAGNETIC ERROR The angle by which a compass direction differs from the true direction; the algebraic sum of the variation and deviation.

COMPASS POINTS

The 32 divisions of a compass, at intervals of 11 ¼°. Each division is further divided into quarter points.

COMPASS ROSE

A circle graduated in degrees, clockwise from 0° at the reference direction to 360°, and sometimes also in compass points. Compass roses are placed at convenient locations on the nautical chart or plotting sheet to facilitate measurement of direction.

COMPILATION

The production of a new or revised map or chart, or portions thereof, from existing maps, aerial photographs, survey and other data, and other sources. The process requires the selection, evaluation, assembly, and graphic presentation of all relevant information.

CONCUR/DO NOT CONCUR

Agree or do not agree. Cartographic review comments used to indicate the agreement or non-agreement with regard to the field's charting recommendation concerning specific features.

CONCUR WITH CLARIFICATION

Cartographic agreement, requiring better description without confusion as to the data verification and charting recommendation. In general, this means the cartographic verifier agrees or concurs with the field hydrographer, providing additional comments are added. The note will usually indicate where the additional cartographic comments should be placed, along with additional descriptions that are needed for clarification.

CONE OF SILENCE

In three dimensions, the Cone of Silence is the area that begins at the intersection of two overlapping swaths of multibeam coverage and continues upward to the water's surface. Any object or part of an object that falls within this 'cone' will not be ensonified. The size of this area will be affected by vessel roll. For additional information see Appendix 2 (Cone_of_Silence.pdf).

CONSTANT ERROR

A systematic error which is the same in both magnitude and sign through a given series of observations.

CONTACT IMAGE

A snippet or small graphic image file generated during side scan processing in CARIS HIPS and SIPS.

The image file is written as a *.tif format and resides within the line directory of the side scan data directory (PVDL).

CONTERMINOUS UNITED STATES

Comprises the 48 States of the United States and the District of Columbia; all of the states exclusive of Alaska and Hawaii. They have common boundaries and are not separated by foreign territory or the high seas.

CONTIGUOUS ZONE

1. A zone seaward of the territorial sea in which coastal states may assert jurisdiction short

of complete sovereignty. Article 24 of the Convention on the Territorial Sea and the Contiguous Zone authorizes such a zone "to prevent infringement of its customs, fiscal, immigration or sanitary regulations in territory or territorial sea.. . . " Under the Convention, the contiguous area may extend no more than 12 miles from the coast line. 2. The belt of high seas, 9 nautical miles wide, that is adjacent to and seaward of the territorial seas of the United States and that was declared to exist in Department of State Public Notice 358 of June 1, 1972, FR 11906.

CONTINENTAL MARGIN

The zone, generally consisting of shelf, slope, and rise, separating the continent from the abyssal plain or deep sea bottom.

CONTINENTAL RISE

A gentle slope rising from the oceanic depths toward the foot of a continental slope.

CONTINENTAL SHELF

The submerged portion of a continent which slopes gently (average slope of less than 1:100) seaward from the low-water line to a point where a substantial break in grade occurs, at which point the bottom slopes seaward at a considerable increase in slope (typically exceeding 1:40) until the great ocean depths are reached. The point of break defines the "edge" of the shelf, and the steeper sloping bottom the continental slope. Conventionally, the edge is taken at 100 fm (or 200 m), but instances are known where the increase in slope occurs at more than 200 fm or less than 65 fm. Alternate juridical (legal) definition: Under the UN Conference on Law of the Sea, Article 76, the continental shelf of a coastal State comprises the seabed and subsoil of the submarine areas that extend beyond its territorial sea throughout the natural prolongation of its land territory to the outer edge of the continental margin, or to a distance of 200 nautical miles from the baselines from which the breadth of the territorial sea is measured where the outer edge of the continental margin does not extend up to that distance. Under certain circumstances a coastal State may submit a claim for an extension of its continental shelf beyond 200 nautical miles.

CONTINENTAL SLOPE

The relatively steep descent from the edge of the continental shelf to the deep-sea floor, usually a very irregular area.

CONTINUOUSLY OPERATING REFERENCE STATIONS (CORS)

A network of continuously operating stations operated by the National Geodetic Survey that provide Global Positioning System (GPS) carrier phase and code range measurements in support of 3-dimensional positioning activities throughout the United States and its territories.

CONTOUR

A line joining points of equal vertical distance above or below a datum. Such a line on a map is a type of isoline.

CONTROL

1. The coordinated and correlated dimensional data used in geodesy and cartography to determine the positions and elevations of points on the land, sea, lake, river, air, etc., or on a cartographic representation of the surface. 2. A collective term for a system of marks or objects on the earth or on a map or photograph, whose positions or elevations (or both) have been or will be determined.

CONTROLLING DEPTH

1. The least depth in the approach or channel to an area, such as a port or anchorage, governing the maximum draft of vessels that can enter. See Federal Project Depth. 2. The least depth within the limits of a channel; it restricts the safe use of the channel to drafts of less than

that depth. The centerline controlling depth of a channel applies only to the channel centerline; lesser depths may exist in the remainder of the channel. The mid-channel controlling depth of a channel is the controlling depth only for the middle half of the channel.

CONTROL STATION A point on the ground whose horizontal or vertical location is used as a basis for obtaining locations of other points.

CONVENTIONAL CHARTS

Flat, printed reproductions published by NOAA of some portion of the navigational part of the Earth's surface. Depending on their scale, these charts show the nature and shape of the coast, depth of the water, general configuration and character of the bottom, prominent landmarks, port facilities, cultural details, dredged channels, aids to navigation, marine hazards, magnetic variations, and seaward boundaries. Changes brought about by people and nature require that nautical charts be constantly maintained to aid safe navigation. NOAA's area of responsibility includes the national and territorial coastal waters of the United States, including the Great Lakes, Puerto Rico, U.S. Virgin Islands, U.S. Trust Territories, and other islands in the Atlantic and Pacific Oceans.

CONVENTION ON THE TERRITORIAL SEA AND THE CONTIGUOUS ZONE

One of the four Conventions on the law of the sea adopted at Geneva in 1958 which, among other things, sets out principles for establishing the baseline from which maritime zones of jurisdiction will be measured. 15 U.S.T 1606. Those principles were later adopted by the United States Supreme Court for purposes of implementing the Submerged Lands Act, 43 U.S.C 1301 et seq. Sometimes referred to herein simply as "the Convention."

COORDINATED UNIVERAL TIME (UTC)

A "time" referencing term which supersedes, but is generally equivalent to, Greenwich Mean Time (GMT). The new UTC time scale is almost perfectly constant, since it is based on stable atomic clocks. GMT is based upon a form of solar time-keeping and is approximately the same as UTC. See Greenwich Mean Time (GMT). UTC is a time scale that is based on the second (SI), as defined and recommended by the CCIR (International Radio Consultative Committee, of the International Telecommunications Union), and maintained by the Bureau International des Poids et Measures (BIPM). For most practical purposes associated with the Radio Regulations, UTC is equivalent to mean solar time at the prime meridian (0° longitude), formerly expressed in GMT. The maintenance by BIPM includes cooperation among various national laboratories around the world. Adjustments to the atomic, i.e., the UTC, time scale consist of an occasional addition or deletion of 1 full second, which is called a leap second. Twice yearly, during the last minute of the day of June 30 and of December 31, Universal Time, adjustments may be made. Historically, adjustments, when necessary, have usually consisted of adding an extra second to the UTC time scale in order to allow the rotation of the Earth to "catch up." Therefore, the last minute of the UTC time scale, on the day when an adjustment is made, will have 59 or 61 seconds. UTC is also called World Time, Z Time, Zulu Time.

COORDINATES

Linear or angular quantities which designate the position of a point in relation to a given reference system.

CORAL

Hard calcareous skeletons of many tribes of marine polyps. In the strict sense, a bottom-dwelling marine organism which secretes an external skeleton of calcium carbonate and which frequently forms large, irregularly shaped colonies with numerous coral heads and pinnacles. Coral formations usually consist of a mixture of coral and other marine organisms, along with other debris and chemically precipitated rock. For shoreline mapping purposes, a coral formation is a naturally occurring, consolidated mass of hard calcareous matter which is too large to be adequately represented on the shoreline map by a single rock (coral) symbol. These formations include masses of irregular shape, as well as those relatively flat, ledge type features that may fringe a shore.

CORAL HEAD

A massive mushroom- or pillar-shaped coral growth.

CORAL REEF

A reef consisting of coral, fragments of coral, and other marine organisms consolidated together so as to form a massive structure.

CORS

See Continuously Operating Reference Stations.

COVE

A small, sheltered recess in a coast, often inside a larger embayment.

COVERS/UNCOVERS

An expression used to indicate an area of a reef or other projection from the bottom of a body of water which periodically extends above and is submerged below the surface. See also Awash.

CRIB

A permanent marine structure usually designed to support or elevate pipelines; especially a structure enclosing a screening device at the offshore end of a potable water intake pipe. The structure is commonly a heavy timber enclosure that has been sunken with rocks or other debris.

CRIT

Informal name for the critical corrections database that is used in the Update Service Branch. The CRIT database was started in 1991 and includes all corrections from the LNM and NM and Canadian Notice. It is used by all cartographers and is a major research tool as well as application history.

CRITICAL SURVEY AREA

Per the NOAA Hydrographic Survey Priorities document, critical survey areas are defined as waterways with high commercial traffic volumes (cargo, fishing vessels, cruise ships, ferries, etc., extensive petroleum or hazardous material transport, compelling requests from users, and/or transiting vessels with low under-keel clearance over the seafloor. Approximately 43,000 square nautical miles of critical survey areas were identified in 1994 by NOAA and given the highest priority for hydrographic survey. New areas are continuously being identified as critical based on changing usage and are designated as emerging critical areas.

CROSSLINES

Sounding lines that cross the main system of survey lines at either right angles or at an oblique angle. Cross line data is acquired, processed, and evaluated as a system check. Crosslines are not an accuracy test or assessment, but a system check comparing data from different times and different line azimuths or directions.

CULTURAL FEATURE

A feature delineated on a survey, map, or chart which represent objects either constructed by, or resulting from the actions of man, e.g., shipwrecks, roads, buildings, canals, piers, etc.

CUPOLA

A small dome-shaped tower or turret rising from a building.

CUPPING/FROWNING (SVP)

A sound speed profile artifact exhibited in MBES data either as a concave or smiling swath (cupping) and convex or frowning swath.

7.4 D

DANGER LINE

1. A line drawn on a chart to indicate the limits of safe navigation for a vessel of specific draft. 2. A line of small dots used to draw the navigator's attention to a danger which would not stand out clearly enough if it were represented on the chart solely by the specific symbols. The line of small dots is also used to delimit areas containing numerous dangers, through which it is unsafe to navigate.

DANGEROUS WRECK A wreck either visible or submerged at such a depth as to be considered a danger to navigation with respect to local vessel traffic. See derelict and wreck.

DANGER TO NAVIGATION (DTON)

Any feature, e.g., a wreck, obstruction, depth, or condition deemed to constitute a potential risk to mariners. Advisory information is published by the U. S. Coast Guard in the Local Notice to Mariners and by National Geospatial-Intelligence Agency (NGA) in the Notice to Mariners.

DAPR

See Data Acquisition and Processing Report. DATA General term used to denote facts, numbers, letters, and symbols. The basic elements of information; usually but not always expressed in numerical form.

DATA ACQUISITION AND PROCESSING REPORT

A project-wide survey report that is separated into three sections: Equipment, Quality Control, and Corrections to Echo Soundings. Refer to NOS Specifications and Deliverables, June 2006 Edition.

DATA FLIERS

Erroneous data points that could be the result of noise interference within the water column, operational parameters or settings such as TVG (time varied gain), pulse widths, pulse lengths, power and/or gain levels.

DATAGRAM

A discrete package of data and headers which contain addresses (which is the basic unit of transmission across an IP network). Also called a ‘packet’.

DATUM

Any numerical or geometrical quantity or set of such quantities which may serve as a reference or base for other quantities. In geodesy a datum is defined by a set of parameters specifying the reference surface or the reference coordinate system. Therefore, two types of datums are required: a horizontal datum which forms the basis for computations of horizontal control surveys and a vertical datum to which elevations or depths are referred.

DATUM CORRECTION

The correction (in latitude and longitude) that must be applied to the projection lines on a survey sheet or chart to transform it to a different datum.

DATUM PLANE

A vertical control datum. Although a level surface is not a plane, the vertical control datum is frequently referred to as the datum plane.

DAYBEACON

An unlighted structure which serves as a daytime aid to navigation by virtue of its distinctive appearance which makes it recognizable and identifiable.

DAY OF YEAR

A sequential numbering system starting with 001 on January 1 of each year and ending with 365, or 366 in leap years, on December 31 of that year. DOY is often incorrectly referred to as Julian Day.

DAYMARK

The identifying characteristics of an aid to navigation, unique and distinctive to facilitate its daytime recognition. Also, a conspicuous target added to a daybeacon or light.

DEADHEAD

A submerged or barely awash log or tree trunk freely floating at varying attitudes, in contrast to the plane formed by the still undisturbed surface of the water. At times, one end of a deadhead may become temporarily attached to the bottom with the opposite (unattached) end floating in a pivotal or vertical manner due to the action of waves and/or currents.

DEAD RECKONING

A method of navigation that has been historically used in hydrographic surveying to control the position of the survey ship beyond the range of control stations, and to supplement astronomic observations. The position is determined by applying the ship's run to the last well-determined position, using the course steered and the distance traveled by the log.

DEADWEIGHT DEPRESSOR

A heavy, inert weight used to increase towfish depth when attached to the tow cable. When using long lengths of in-water cable, such as when towing lightweight towfish in depths greater than 100 m, drag forces on the cable often prevent the towbody from descending to the required depth. Slower tow speeds or greater downward pull at the towbody are required. Although deadweight depressors are more straightforward in application than hydrodynamic depressors, they should be streamlined and rigged as to be tangle-free during and after deployment. The use of deadweights also requires greater overside lifting capacity than with hydrodynamic depressors.

DECIBEL

A logarithmic measurement unit that describes a sound's relative loudness, though it can also be used to describe the relative difference between two power levels. A decibel (dB) is one tenth of a Bel. In sound, decibels generally measure a scale from 0 (the threshold of hearing) to 120-140 dB (the threshold of pain). A 3dB difference equates to a doubling of power. A dB is a unit of measure of signal strength, usually the relation between a transmitted signal and a standard signal source. Every 3 dB = 50% of signal strength.

DECONFLICT

The process of reconciling conflicting information based on the age of the information, reliability of the source, etc.

DELTA

The low alluvial land, deposited in a more or less triangular form at the mouth of a river, which is often cut by several tributaries of the main stream.

DEMARCATION LINE

A line through the high seas marking the allocation of territory between two countries, rather than a boundary line; for example, the line through the Bering Strait and Bering Sea between Russia and Alaska.

DENSITY OF SOUNDINGS

Intervals between lines of soundings and soundings within the same line. Density of soundings depends heavily on the scale and nature of the survey and type of sounding equipment used.

DENSITY OF WATER

Mass per unit volume. The reciprocal of specific volume. In oceanography, the density of sea water is numerically equivalent to specific gravity and is a function of salinity, temperature, and pressure.

DEPRESSION CONTOUR

A closed contour delimiting an area of lower elevation than the surrounding terrain. Directional ticks extend from the contour in a downhill direction.

DEPRESSOR

An attachment to a sonar tow cable or towed body that assists in increasing the depths of the towed body; commonly of two types, deadweight and hydrodynamic. The depressor allows the user to bring a sonar towbody within an optimum altitude above the seabed. Although lower tow speeds also assist in lowering a towfish, speeds below 1 - 1.5 knots may produce towbody instability such as kiting and yaw, resulting in data distortions.

DEPTH

The vertical distance from a given water level to the seafloor, lake or river bottom.

DEPTH CONTOUR NAVIGATION

A method of position determination by utilizing the depth curves on the nautical chart. Consists in fitting a series of observed echo soundings to the depth curves. The line of soundings is fitted to the depth contours by moving it so that it remains parallel to the true course steered.

DEPTH CURVES

A line on a map, smooth sheet, or nautical chart drawn in accordance with prescribed conventions and generally connecting points of equal depth at or below a specified datum. The line is sometimes significantly displaced outside of soundings, symbols, and other chart detail for clarity as well as generalization. Depth curves therefore often represent an approximate location of the line of equal depth as related to the surveyed line delineated on the source.

DEPTH UNITS

The units (fathoms, feet, meters) in which the soundings are plotted on the smooth sheet or on the nautical chart. On early surveys, two depth units were generally used on one survey, but with no uniform dividing line (see Registry Nos. H-1 (1837) and H-336 (1852)).

DERELICT

A vessel or any property abandoned and afloat within navigable waters and thereby constituting a real or potential danger to navigation.

DESCRIPTIVE REPORT (DR)

A written report that accompanies every topographic and hydrographic survey for the purpose of supplementing it with information that cannot be shown graphically thereon, and to direct attention to important results.

DETACHED POSITION (DP)

A discrete geographic position observed and recorded at a specific location. The position is "detached" from the main scheme of hydrographic sounding lines. Rocks, wrecks, obstructions, aids to navigation, etc., are typically the sort of features subject to this type of positioning.

DETECTABILITY

The size, shape and makeup of a seabed anomaly, as related to a sonar's ability to discern its existence. Detection occurs when excess energy is returned to the sonar transducer from a target or discontinuity. When a target returns this excess energy from only one of many pings, the system will detect the target but the operator may not recognize it in the data. Some modern sonar data processors are assisting the user in narrowing the gap between detection and recognition with separate graphic displays of the amplitude of individual return signals. See Recognition.

DEVIATION

The angle between the magnetic meridian and the axis of a compass card, expressed in degrees east or west to indicate the direction in which the northern end of the compass card is offset from magnetic north. Deviation is caused by disturbing magnetic influences in the immediate vicinity of the compass, as within the craft.

DEVIATION OF COMPASS

The deflection of the needle of a magnetic compass due to masses of magnetic metal within a ship on which the compass is located. This deflection varies with different headings of the ship. The deviation is called easterly and marked plus (+) if the deflection is to the right of magnetic north, and is called westerly and marked minus (-) if it is to the left of magnetic north. A deviation table is a tabular arrangement showing the amount of deviation for different headings of the ship. Each compass requires a separate deviation table.

DIFFERENTIAL GLOBAL POSITIONING SYSTEM (DGPS)

Differential Global Positioning System (DGPS) is an enhancement Global Positioning System that uses a network of fixed ground based reference stations to broadcast the difference between the positions indicated by the satellite systems and the known fixed positions. These stations broadcast the difference between the measured satellite pseudoranges and actual (internally computed) pseudoranges, and receiver stations may correct their pseudoranges by the same amount.. Differential corrections can be applied in either real time or post-processing.

DIFFERENTIATION

The process of using separate but identical navigational instruments where one is fixed at a known location and provides, via radio link, a second mobile instrument with offset calculations. This process is used to increase the accuracy of certain navigational instruments that may be affected by diurnal or atmospheric variations, such as LORAN, and those with inherent errors, such as GPS.

DIGITAL CARTOGRAPHIC FEATURE FILE (DCFF or CFF)

National Geodetic Survey's deliverable file that stores geometry and attribute information for spatial features in a vector data set. The previous file formats included Standard Digital Data Exchange Format and ArcInfo Interchange file (E00). The current format is the ESRI Shapefile using the Coastal Cartographic Object Attribute Source Table (C-COAST) attribution schema.

DIGITAL MAP (DM)

The National Geodetic Survey's Coastal Mapping Program's series identifier for shoreline data contained within the Digital Cartographic Feature File (DCFF) used from 1990 to 1999. The file identifiers consisted of two alpha and five numeric characters. The alpha characters were DM, which reflect Digital Map while the numbers ranged from DM10000 to DM10404.

DIGITAL TERRAIN MODEL

A surface, typically land or seafloor, represented in digital form by an elevation grid or lists of three-dimensional coordinates.

DIKE A bank of earth or stone used to form a barrier, frequently and confusingly interchanged with levee. A dike restrains water within an area that is normally flooded.

DILUTION OF POSITION (DOP)

A measure of the geometry of the satellites seen by the receiver. DOP relates the statistical accuracy of the satellite measurements to the statistical accuracy of the computed solution. Position Dilution of Precision (PDOP) is a common measure, composed of Horizontal Dilution of Precision (HDOP) and Vertical Dilution of Precision (VDOP). Geometric Dilution of Precision (GDOP) is composed of Time Dilution of Precision (TDOP) and PDOP. The larger the DOP, the less accurate the measurement.

DIPFILE

An automated Discrete Independent Point File once maintained within NOAA's nautical chart program which listed charting sources and geographic positions of cartographic features, such as navigational aids, landmarks, wrecks, and obstructions. Elements of the DIPFILE were/are being used in the initial encoding of Electronic Navigational Charts.

DIRECTION

In surveying and mapping, the angle between a line or plane and an arbitrarily chosen reference line or plane.

DIRECTION LIGHT

A light illuminating a sector of very narrow angle and intended to mark a direction to be followed. A direction light bounded by other sectors of different characteristics which define its margins with small angles of uncertainty is called a single station range light.

DISCOLORED WATER Unnatural colored areas in the sea due to the existence of shoals. Sea water having a color other than the blues and greens normally seen. Variations of the colors red, yellow, green, and brown, as well as black and white, have been reported. Discolorations may appear in patches, streaks, or large areas, and may be caused by concentrations of inorganic or organic particles or plankton.

DISCONTINUITY

In NOAA hydrography, a change in the make-up of a body of water that causes a change in the speed and/or direction of sound propagation, of an incident sonar pulse. In contrast to an anomaly, which is usually distinct and separate within the environment, discontinuities are often widespread and difficult to discern as distinct. These include haline changes in the water, aerated or cavitated bodies of water, and thermoclines.

DISPOSAL AREA

Area designated by the Corps of Engineers for depositing dredged material, where existing depths indicate that the intent is not to cause sufficient shoaling to create a danger to surface navigation. Disposal areas are shown on nautical charts. See also dumping grounds, dump site, spoil area.

DIURNAL TIDE

A tide in which the tidal cycle consists of one high water and one low water each tidal day. In British terminology also called a single day tide.

DOCK

The slip or waterway between two piers, or cut into the land for the berthing of ships. A pier is sometimes erroneously called a dock.

DOLPHIN

A mooring post or buffer placed at the entrance of a dock, alongside a wharf, or in the middle of a stream. In the first and second instances it is used as a buffer. In the third, it is used as a mooring post by vessels which discharge their cargoes without going alongside a dock or wharf. Each dolphin is generally composed of a series of heavy piles contiguous to one another. They are arranged in a circle, brought together, and capped over the top.

DOME

A large rounded hemispherical structure rising from a building or a roof of the same shape.

DOP

See Dilution of Position.

DOPPLER POSITION SYSTEM

A positioning system consisting of a radio receiver at the point whose coordinates are to be determined, one or more beacons in orbit about the Earth, and a computing system for determining the orbits of the beacons. The difference between the frequency of a radio wave as received and its frequency as transmitted from the beacon is a function of the radial velocity of the source with respect to the receiver. Given the ephemeris of the beacon, the coordinates of the receiver can be calculated from measurements of the difference in frequency.

DOUBTFUL SOUNDING

A depth shown on a chart over a shoal, a rock, etc., that may be less than that indicated, the position not being in doubt.

DOWNSAMPLING

The process of reducing the number of data points in a data set, generally by keeping shoaler soundings when they are near deeper soundings. DP See Detached Position. DR See Descriptive Report.

DRAFT

The vertical distance, at any section of a vessel from the surface of the water to the bottom of the keel. When measured at or near the stem, it is referred to as draft forward and when measured at or near the stern as draft aft. For a hydrographers, draft refers to the vertical distance from the surface of the water to the transducer face.

DRAG

The hydrodynamic forces exerted on the components of a body in contact with a moving fluid. In the case of a towed assembly, drag tends to reduce its forward motion.

DREDGED CHANNEL

An artificially maintained sea lane extending from an inland water body into the marginal sea to accommodate vessel traffic through coastal shallows.

DRY DOCK

An artificial basin fitted with gate or caisson into which a vessel may be floated and from which the water may be pumped out to expose the bottom of the vessel.

DRYING HEIGHTS

Heights above chart sounding datum of those features which are periodically covered and exposed by the rise and fall of the tide.

DTM

See Digital Terrain Model.

DTON

See Danger to Navigation.

DUCK BLIND

For agency charting purposes, a duck blind is a nonfloating structure, used for concealing waterfowl hunters, usually consisting of a wooden framework covered with brush. They pose a special problem for the cartographer. They are essentially unreported to any charting authority when built. They are unlighted and often constructed in navigable water without regard to the possible hazard they pose, especially to the small craft operator. Many are substantial structures built on piles. Even after they are eventually reduced to ruins the pilings may persist for years.

DUMPING GROUNDS

Although shown on nautical charts as dumping grounds in U.S. waters, the federal regulations for these areas have been revoked and their use for dumping discontinued. These areas will continue to be shown on nautical charts until such time as they are no longer considered to be a danger to navigation.

DUMP SITE

Area established by federal regulation in which dumping of dredged and fill material and other nonbuoyant objects is allowed with the issuance of a permit. Dump sites are shown on nautical charts.

7.5 E

EARTH CENTERED, EARTH FIXED (ECEF)

A Cartesian coordinate system beginning at the Earth's center of mass. The Z-axis is aligned with the Earth's mean spin axis. The X-axis is aligned with the zero meridian. The Y-axis is 90 degrees west of the X-axis, forming a right-handed coordinate system.

EBB CURRENT

The movement of a tidal current away from shore or down a tidal river or estuary.

ECDIS

See Electronic Chart Display and Information System.

ECHOGRAM

The graphic representation of echosoundings recorded as a continuous profile of the bottom. Often erroneously called a fathogram when not recorded by a Fathometer.

ECHO SOUNDER

An instrument for determining the depth of a body of water or of an object below the surface by measuring the travel time of an acoustical signal.

ECHOSOUNDING

A method for determining the depth of water by measuring the time interval between the emission of an acoustic pulse at or near the water surface and its echo from the bottom.

EDITION DATE

The date of first publication of a chart, or the date when a new edition is printed.

EELGRASS

A submerged marine plant with very long narrow leaves.

ELECTRONIC CHART DISPLAY AND INFORMATION SYSTEM (ECDIS)

The navigation information system which is considered the legal equivalent of the nautical chart, displaying selected information from an electronic navigational chart (ENC) integrated with data from positional and, optionally, other sensors.

ELECTRONIC CHART SYSTEM (ECS)

A navigation information system that electronically displays vessel position and relevant nautical chart data and information from the ECS database on a display screen, but does not meet all the IMO requirements for ECDIS and is not intended to satisfy the SOLAS chapter V requirement to carry a navigational chart.

ELECTRONIC NAVIGATIONAL CHART (ENC)

A vector representation of a nautical chart, intended to be used in conjunction with ECDIS (Electronic Chart Display and Information Systems). ENC's are standardized as to content, structure and format and may contain supplementary nautical information useful for safe navigation.

ELECTRONIC POSITIONING SYSTEM

A positioning system in which the travel time or phase shift of radio waves from fixed points on land was measured. Short range systems measured travel time of a direct wave using an ultra high frequency (UHF) signal. Medium range systems measured phase shift of a ground wave that utilized a much lower frequency. These systems were essentially made obsolete by the advent of GPS in the 1990's.

ELEVATION MASK

An adjustable feature of GPS receivers that specifies a satellite must be a certain number of degrees above the horizon before its signals are used for positioning. Satellites at low elevation angles (five degrees or less) have lower signal strengths and are more prone to loss of lock, thus causing noisy solutions.

ELEVATION

The vertical distance of natural and artificial objects above an adopted reference plane. On nautical/navigational charts the elevations of bare rocks, bridges, landmarks, and lights are referenced to the plane of mean high water; contour and summit elevations are referenced to mean sea level, if the source for such information is referenced to this plane.

ELLIPSOID (or Reference Spheroid)

A mathematical figure generated by the revolution of an ellipse about one of its axes. The ellipsoid that approximates the geoid is an ellipse rotated about its minor axis. An ellipsoid serves as the mathematical model from which maps and charts are produced. However, numerous ellipsoids have been developed to support local datums. The use of the WGS 84 ellipsoid provides a single standard of reference within the Department of Defense. Also called spheroid of reference, or ellipsoid of reference. See Geoid, Oblate Spheroid, Reference Spheroid.

ELLIPTICITY OF THE SPHEROID

The ratio of the difference between the equatorial (a) and polar (b) radii of the earth (major and minor semi-axes of the spheroid) and its equatorial radius, or (a-b)/a. Also called flattening of the earth.

EMBANKMENT

An artificial deposit of material that is raised above the natural surface of the land and used to contain, divert, or store water, to support roads or railways, or for other similar purposes.

EMBAYMENT

Any indentation of a coast, regardless of width, at the entrance or depth of penetration into the land.

ENC VIEWER

Software capable of viewing S-57 format ENC files, i.e., CARIS Easy ENC, Seven C’s, etc.

ENSONIFY

To expose an area, or portion of seabed, to acoustic energy. Seabed that has been covered by sonar, is said to have been ensonified. Ping rates (numbers of output pulses per second) are often referred to as "ensonification rates."

EPHEMERIS

The set of parameters used by a global navigation satellite receiver to predict the location of a satellite and its clock behavior. Each satellite contains and transmits ephemeris data about its own orbit and clock. Ephemeris data is more accurate than the almanac data, but is applicable over a short time frame from 4 - 6 hr.

ERROR

The difference between an observed or computed value of a quantity and an ideal or true value of that quantity.

ESTIMATED POSITION

The most probable position of a craft determined by incomplete data or data of questionable accuracy. Such a position might be determined by applying a correction to the dead reckoning position.

ESTUARY

An embayment of the coast in which fresh river water entering at its head mixes with the relatively saline ocean water. When tidal action is the dominant mixing agent it is usually termed a tidal estuary. Also, the lower reaches and mouth of a river emptying directly into the sea where tidal mixing takes place. The latter is sometimes called a river estuary.

EVALUATION REPORT

The successor to the Verifier’s Report, with format and content essentially unchanged. See also Review and Review Report.

EVENT MARK

A mark or notation put on a sonar record, or embedded in stored data, representing the moment of a navigational fix or other critical occurrence during a survey. Event marks are important in assessing progress of a survey and in tying navigation logs to sonar data. Modern computer data processors which geo-code every sonar ping have simplified the practice of manual log keeping, but event marks are still important as progress references and data-related geodetic markers.

EXCLUSIVE ECONOMIC ZONE (EEZ)

An area, not exceeding 200 nautical miles from the baselines from which the breadth of the territorial sea is measured, subject to a specific legal regime established in the United Nations Convention on the Law of the Sea under which the coastal state has certain rights and jurisdictions.

EXISTENCE DOUBTFUL

Of uncertain existence. The expression is used principally on charts to indicate the possible existence of a rock, shoal, etc., the actual existence of which has not been verified. Usually shown by the abbreviation “E.D.”

7.6 F

F SURVEY

See Field Examination.

FAIRWAY

That part of a river, harbor, etc., where the main navigable channel for vessels of larger size is located. The usual course followed by vessels entering or leaving harbor. Also called ship channel. The word “fairway’ has been generally interpreted to include any navigable water on which vessels of commerce habitually move, and therefore, embraces the water inside channel buoys where light-draft vessels frequently navigate and not merely the ship channel itself.

FALSE ORIGIN

A fixed point to the south and west of a grid zone from which grid distances are measured eastward and northward. Also called a grid origin.

FAST LAND

Land inshore of the inner edge of a marsh; usually at or above the plane of mean high water.

FAST SHORELINE

The line appearing on a shoreline map that separates water from fast, natural uplands. This line should not be confused with the approximate back limits of marsh or marine vegetation which is normally compiled shoreward from an apparent shoreline and in lieu of the fast shoreline.

FATHOGRAM

A graphic record of depth measurements obtained by a Fathometer. Frequently, the term is improperly used to refer to an echogram.

FATHOM

A unit of length equal to 6 ft (1.82880 m), and used principally as a measure of depth of water.

FATHOMETER

Copyrighted trade name for a type of single beam echo sounder. Often incorrectly used to identify any echosounder.

FE

See Field Examination.

FEATURE

Any single-source item that is significant enough to warrant cartographic and/or hydrographic representation. See Cartographic Feature.

FEDERAL PROJECT

A navigation channel or maintenance dredging activity of any nature and for any purpose that is to be performed by or for the United States Army Corps of Engineers (USACE).

FEDERAL PROJECT DEPTH

The design dredging depth of a channel constructed by the U.S. Army Corps of Engineers

(USACE); the project depth may or may not be the goal of maintenance dredging after completion of the channel. For this reason federal project depth must not be confused with controlling depth.

FETCH

The distance along open water or land over which the wind blows; the distance traversed by waves without obstruction.

FIELD EDIT

The process of on-site examinations and measurements designed to ensure that detail and nomenclature, as portrayed or described on a previously compiled document, is current, reliable, and adequate for its intended purpose. The purpose of these documents, which may have been in graphic or tabulated form, was to provide data for the nautical charting program.

FIELD EXAMINATION (FE)

Hydrographic surveys intended to cover only limited areas. Each survey is assigned a unique registry number the format of which has varied over time. The original form was F.E. No. (consecutive number by year) (year), for example, F.E. No. 5 1945. This format was revised in 1980 to FE-(consecutive number), for example, FE-112. The format was later revised to its present form, F(consecutive number), for example, F0025.

FIELD POSITION

An unadjusted, geographic position of a point on the earth, computed while field work is in progress to determine the acceptability of the observations or to provide a preliminary position for other purposes.

FIELD SHEET

The system CARIS HIPS and SIPS uses for organizing data products created from cleaned and processed bathymetry and side scan data. The field sheet consists of a data directory with a field sheet definition file and a CARIS file for storing vector products. The definition file contains information about the geographic boundary of the field sheet and the coordinate system to be used for the data products. (Former use: The hydrographer's or topographer's work sheet; the fieldsheet presents a graphic display of all surface and subsurface features in the area.)

FIGURE OF THE EARTH

The defining elements of the mathematical surface which approximates the surface of the geoid. The figure of the earth has been proved to be approximately an oblate spheroid. See also Geoid and Spheroid.

FILE TRANSFER PROTOCOL (FTP)

Method of transferring usually large files across network connections.

FINAL WATER LEVEL CORRECTORS

Verified 6-minute water levels (see Verified Water Levels) for which CO-OPS has provided final discrete zoning. These data are often referred to as "Smooth Tides".

FINGER PIERS

Small piers which extend from a larger main pier.

FIRMWARE

Coded instructions related to processor function, and sometimes data processing algorithms, embedded as integral portions of the internal circuitry of an electronic system.

FIRST BOTTOM RETURN

The component of a side scan sonar record representing the shortest acoustic path between the towfish and the seabed directly below the towfish. The first bottom return is utilized by many sonar systems to determine fish height (altitude), which is important in the algorithms used for range compression correction. In uncorrected data, the operator will use the first bottom return as a measure of fish height for winch in/out commands to maintain proper towing altitudes. This feature of the sonar display will be very strong in hard bottom or over a rocky substrate, but may be difficult to discern over a mud or silt seabed.

FIRST SURFACE RETURN

The component of a side scan sonar record representing the shortest acoustic path between the towfish and the surface directly above the towfish. Because the vertical beamwidth is very wide in side scan sonar, some of the acoustic energy propagates upwards from the transducer. Although this energy is very low level, the sea surface can be a good reflector and return enough of the incident pulse to be noticeable in data. As the fish is lowered, the first surface return moves, in the water column portion of the record, away from the centerline. In shallow water operations, as the fish is lowered past the half-depth point, this return becomes lost in the near range data. Beyond this it may not be discernible because of its low signal strength. In shallow water, when the first surface return crosses the first bottom return, the towfish is halfway between the surface and the seabed.

FISH HAVEN

An area established by private interests, usually sport fishermen, to simulate natural reefs and wrecks that attract fish. The reefs are constructed by dumping assorted material in areas which may be of very small extent or may stretch a considerable distance along a depth contour. Fish havens have defined authorized boundaries and minimum clearances, both of which are shown on nautical charts.

FISH HEIGHT

The distance between a side scan sonar towfish and the seabed, usually measured in feet or meters.

FISH TRAP

A device for catching fish. It usually consists of stakes and nets arranged such that fish entering are prevented from exiting.

FISH TRAP AREA

An area established by the Corps of Engineers in which traps may be built and maintained according to established regulations. The fish stakes which may exist in these areas are obstructions to navigation and may be dangerous. The limits of fish trap areas and a cautionary note are usually charted.

FIX

A position determined without reference to any former position. In concept, a fix is the common intersection of two or more lines of position obtained from simultaneous observations not dependent upon any former position. In normal practice, a fix is the most probable position derived from 2 or more intersecting lines of position obtained from observations made at nearly the same time.

FJORD

A long narrow arm of the sea, usually formed by the entrance of the sea into a deep glacial trough.

FLASHING LIGHT

A light in which the total duration of light in a period is shorter than the total duration of darkness and appearances of light (flashes) are usually of equal duration.

FLATS

A place covered with water too shallow for navigation with vessels ordinarily used for commercial purposes; the space between high- and low-water marks along the edge of an arm of the sea, a bay, tidal river, etc.

FLIERS

Outliers. Soundings which are not associated with the seafloor. See Data Fliers.

FLOAT

A floating structure, usually rectangular in shape, which generally serves as a landing or pier head.

FLOATING BREAKWATER

A breakwater consisting of a series of logs or timbers chained or lashed together and secured by chains or cables attached to anchors or large blocks of stone, so as to form a protected basin for the mooring or anchoring of vessels.

FLOATING DOCK

1. A floating dock is a platform or ramp supported by pontoons. These are usually joined to the shore with a ramp that rests upon the dock on rollers, to adjust for the vertical movement of the dock. The dock is usually held in place by vertical poles embedded in the soil under the water or by anchored cables. 2. A form of dry dock consisting of a floating structure of one or more sections which can be partly submerged by controlled flooding to receive a vessel, then raised by pumping out the water so that the vessel's bottom can be exposed.

FLOOD

The movement of a tidal current toward the shore or up a tidal river or estuary.

FLY-AWAY STATION

A GPS station that is established by a survey unit to provide local differential GPS correctors for positioning that is more accurate than stand alone GPS. Fly-away stations are often established in remote areas where publicly available DGPS positioning in not available. The station consists of a VHF broadcast tower, GPS receivers, computers for data downloads, and batteries. The station is usually set up in an open space on high ground.

FOLIO CHARTS

NOS charts consisting of two to four sheets printed front and back, folded, and bound in a protective cardboard jacket.

FOOTPRINT

The area of seabed ensonified by an outgoing sonar beam during, or after, a specific period of time. A smaller footprint of sonar on the seabed will result in a higher resolution image in the data.

FORELAND

A cape or peninsula.

FORESHORE

That part of the shore lying between the crest of the seaward berm (or the upper limit of wave wash at high tide) and the ordinary low-water mark According to riparian law, the strip of land between the high- and low-water marks that is alternatively covered and uncovered by the flow of the tide.

FORMLINE

Broken lines resembling contour lines but representing no actual elevations, which have been sketched from visual observation or from inadequate or unreliable map sources, to show collectively the shape of the terrain rather than the elevation.

FOUL AREA

1. An area where numerous hazards to navigation may cause damage to vessels entering or transiting the area. 2. An area in which hazardous rocks or other obstructions are too numerous to be located individually during a hydrographic survey or cartographically depicted individually. Such areas shall be delimited by a surveyed dashed line. Unless annotated otherwise, a note "foul" within such a delimited area will be construed as foul with rocks. The term "foul" should not be applied to a soft continuum with indefinite boundaries such as mud or sand; to areas congested with marine vegetation such as kelp or grass in water; or to materials not likely to cause damage to a vessel.

FOUL BERTH

A berth in which a vessel cannot swing to her anchor or moorings without fouling another vessel or striking an obstruction.

FOUL BOTTOM

A hard, uneven, rocky, or obstructed bottom having poor holding qualities for anchors, or one having rocks or wreckage that would endanger an anchored or transiting vessel.

FOUL GROUND

An area where the holding qualities for an anchor are poor, or where danger of striking or fouling the ground or other obstructions exist. Examples would be areas strewn with rocks, boulders, coral or obstructions.

FRINGING ISLANDS

A series of islands that fringe, or mask, a mainland coast. Often known as barrier islands.

FRINGING REEF

A reef attached to and paralleling a shore.

7.7 G

GAIN

A measure of the increase in signal amplitude produced by an amplifier. In sonar applications, gains are most often applied in two ways. One is time-varied-gain (TVG), where signal amplification increases as a function of time. This methodology can be applied because there is a constant speed of sound underwater for most sonar applications and the returning signal level from the seabed decreases as the pulse travels across the seabed and away from the transducer. Closer returns have a far higher intensity than distant ones. The other method of increasing gains in sonar is to apply them to the display only. In hard copy recorders, printer gain will darken the record, and with computerized sonar processors, increasing video intensity has a similar effect.

GAUSSIAN ERROR

Deviation of a magnetic compass due to transient magnetism which remains in a vessel's structure for short periods after the inducing force has been removed. This error usually appears after the vessel has been on the same heading for a considerable time.

GENERAL CHARTS

Nautical charts which are published at scales from 1:150,001 to 1:600,000 and are intended for coastal navigation when a course is well offshore but can be fixed by landmarks, lights, buoys, and characteristic soundings.

GENERALIZATION

The process of reducing the complexity of a presentation of map information to make it appropriate for a particular scale of product. For example, shoreline which shows detailed information about a cove at a large scale may only show a small indentation on a small-scale chart.

GEO-CODED

Geographically referenced, usually when associated with an image file registered using a GIS system.

GEODESY

The science related to the determination of the size and shape of the earth (geoid) by such direct measurements as triangulation, leveling, and gravimetric observations. Geodetic observations document and explain the external gravitational field of the earth and, to a limited degree, its internal structure.

GEODETIC CONTROL

A system of horizontal and/or vertical control stations that have been established and adjusted by geodetic methods and in which the shape and size of the Earth (geoid) have been considered in position computations.

GEODETIC COORDINATES

The quantities of latitude, longitude, and height (ellipsoid), which define the position of a point on the surface of the earth with respect to the reference spheroid. Also imprecisely called geographic coordinates.

GEODETIC DATUM

The adopted position in latitude and longitude of a single point to which the charted features of a vast region are referred. It consists of five quantities; the latitude and longitude of the point; the azimuth of a line from this point to another point to which it is tied by the triangulation; and two constants necessary to define the terrestrial spheroid.

ELLIPSOID HEIGHT

The distance from a point to the reference ellipsoid along a line normal to the ellipsoid. The difference between a point's ellipsoid height and its orthometric height equals the geoidal height.

GEODETIC POSITION

A position of a point on the surface of the earth expressed in terms of geodetic latitude and geodetic longitude. A geodetic position implies an adopted geodetic datum.

GEODETIC SURVEY

A survey in which the figure and size of the Earth is considered. It is applicable for large areas and long lines and is used for the precise location of basic points suitable for controlling other surveys.

GEOGRAPHIC CELL (GC)

The current National Geodetic Survey's Coastal Mapping Program's series identifier for shoreline data contained within the Digital Cartographic Feature File (DCFF). Geographic Cells replaced the DM series of DCFFs which superseded the registry numbers (e.g. T and TP) used to identify topographic survey manuscripts. The GC series identifier consists of two alpha and five numeric characters. The alpha characters are "GC" for Geographic Cells while the five numeric characters are a continuation of the DM series numbers (GC10405 being the first GC).

GEOGRAPHIC COORDINATES

The world-wide system of latitude and longitude used to define the location of any point on the earth’s surface.

GEOGRAPHIC INFORMATION SYSTEM (GIS)

A system of spatially referenced information, including computer programs that acquire, store, manipulate, analyze, and display spatial data.

GEOGRAPHIC NUMBER

The number assigned to an aid to navigation for identification purposes in accordance with the lateral system of numbering.

GEOGRAPHIC POSITION

The position of a point on the surface of the Earth expressed in terms of latitude and longitude, either geodetic or astronomic. NOAA uses the term for positions on a geodetic datum.

GEOID

The figure of the earth, which approximates a mean sea level surface extended continuously through the continents. The actual geoid is an equipotential surface to which, at every point, the plumb line (direction in which gravity acts) is perpendicular. Geoids currently in use are GEOID84 and GEOID90.

GLOBAL POSITIONING SYSTEM (GPS)

A constellation of 24 satellites operated by the U.S. Department of Defense which orbit the earth at a very high altitude. GPS satellites transmit signals that allow one to determine, with great accuracy, the locations of GPS receivers. The receivers can be fixed on the Earth, in moving vehicles, aircraft, or in low-Earth orbiting satellites. GPS is used in air, land and sea navigation, mapping, surveying and other applications where precise positioning is necessary. GPS can provide highly accurate position and velocity information in three dimensions and precise time and time interval on a global basis continuously.

GRAPHIC SCALE

A line or bar on a map or chart subdivided to represent distances on the earth in various units, to wit: nautical miles, statute miles, yards, feet, kilometers, etc. Also called bar scale or linear scale.

GRASSY SHOAL

Marsh in the early stages of development often found contiguous to a well-defined marsh or outside the high-water line.

GRATICULE

The network of lines representing meridians and parallels on a map, chart, plotting sheet, etc.

GRAVEL

1. Loose, rounded fragments of rock, larger than sand, but smaller than cobbles. 2. Small stones and pebbles, or a mixture of these with sand.

GRAZING ANGLE

The angle at which a sonar pulse strikes, and propagates across, the seafloor. The grazing angle of the sonar pulse has an effect on the reverberation or backscatter of the ensonified seabed. Grazing angle algorithms in side scan sonar systems attempt to compensate for these changes and produce a uniform image in the sonar data.

GREENWICH MEAN TIME (GMT)

Mean solar time at the meridian of Greenwich, England. It has been used as a basis for standard time throughout the world. Also called Coordinated Universal Time (UTC).

GREENWICH MERIDIAN

The meridian of the Royal Observatory, Greenwich, England. Adopted in 1884 by a conference of nations as the initial or zero of longitudes for all nations.

GRID

A series of lines, usually straight and parallel, or two sets of mutually perpendicular lines, dividing a map, chart, or other representation of the earth's surface into squares or rectangles to permit the location of any point by a system of rectangular coordinates or to serve as a directional reference for navigation. A grid is not necessarily a graticule, and the terms should not be used interchangeably.

GRIDDING

A process used to thin dense hydrographic data by determining a depth at a "grid node" (intersection point of perpendicular grid lines) by considering points in proximity to that grid node – usually a radial distance.

GROIN

A low artificial wall-like structure of durable material extending from the land to seaward for a particular purpose, such as to protect the coast or to force a current to scour a channel. Groins may be classified as permeable or impermeable: impermeable groins have solid or nearly solid structure, permeable groins have openings through them of sufficient size to permit passage of appreciable quantities of littoral drift.

GROSS ERROR

The result of carelessness or a mistake; may be detected through the repeating of the measurement. Also called blunder.

GROUNDING

The touching of the seafloor by a vessel or by the wire sweep during a wire-drag survey.

GROUND SURVEY

A survey made by ground methods, as distinguished from an aerial survey. A ground survey may or may not include the use of photographs.

GROUP REPETITION INTERVAL (GRI)

Of a particular LORAN-C chain, the specified time interval for all stations of the chain to transmit their pulse groups. For each chain a minimum group repetition interval (GRI) is selected of sufficient duration to provide time for each station to transmit its pulse group and additional time between each pulse group so that signals from two or more stations cannot overlap in time anywhere within the coverage area. The GRI is normally stated in terms of tens of microseconds, i.e., the GRI having a duration of 79,900 microseconds is stated as 7990. In providing means for identifying a chain within a system all stations of which transmit on the same frequency (100 kHz), the GRI is the chain signature.

GULF

A tract of water within an indentation or curve of the coastline, in size between a bay and a sea – the Gulf of California, for example.

GULF COAST LOW WATER DATUM (GCLWD)

A tidal datum used as chart datum for the coastal waters of the Gulf coast of the United States from November 14, 1977to November 27, 1980. GCLWD is defined as mean lower low water (MLLW) when the type of tide is mixed and mean low water (MLW) when the type of tide is diurnal. This was replaced by MLLW on November 28, 1980 by the National Tidal Datum Convention of 1980.

GYROSCOPE (GYRO)

A rapidly rotating mass free to move about one or both axes perpendicular to the axes of rotation and to each other. It is characterized by gyroscopic inertia and precession. This term refers colloquially to the gyrocompass.

7.8 H

H-CELL

The S-57 map in CARIS HOM containing all of the new survey and chart information necessary for updating or creating a new ENC and chart product. The CARIS map is referred to as an H-Cell at any stage in CARIS HOM processing.

H-CELL DELIVERABLE

The S-57 Base Cell File (*.000) exported and converted to charting units in HOM.

H DRAWING

Compiled drawing of the nautical chart reflecting revisions based upon source data, such as hydrographic surveys or other sources.

H SURVEY

Refers to a Basic Hydrographic Survey because registry numbers for Basic Hydrographic Surveys begin with the letter “H”. A basic survey is one that is so complete and thorough it does not need to be supplemented by other surveys.

HACHURES

Short lines or wedge shaped marks on topographic maps or nautical charts to indicate the slope of the ground or the submarine bottom. They usually follow the direction of the slope. Hachures may be used to identify a steep coast, but unlike contours they do not show degree of slope or actual elevation of ground above chart datum. They may also be used to accentuate a spot elevation on very small-scale charts without contours.

HAND LEAD

A light sounding lead (7 to 14 pounds), usually having a line of not more than 25 fm.

HARBOR

A place where ships may find shelter. A harbor may be natural or artificially constructed. In either case its waters are inland. The limits of its inland waters are determined, at least in part, by their use as a harbor rather than the mere application of delimitation principles to geography, as is the case with bays and rivers.

HARBOR CHARTS

Nautical charts published at scales of 1:50,000 and larger, and intended for navigating in harbors and smaller waterways and for anchorage.

HARBOR LINE

Lines prescribed by the Corps of Engineers (USACE), which limit the length of piers and other structures projecting into navigable channels; the construction of structures channelward of this line is not permitted unless the harbor lines are modified. Navigation improvements and surveys by the (USACE) do not extend inside (shoreward of) the harbor lines. Harbor lines are of two types, pierhead lines and bulkhead lines. Bulkhead lines are prescribed where the waterfront construction is of a solid nature, such as marginal wharves, backfilled seawalls and bulkhead wharves; the water areas inside bulkhead lines normally may be filled in by private concerns upon proper application to the USACE. Pierhead lines are associated with open-type construction, such as open pile piers, and no such structure may extend channelward of these lines. For waterfronts where both types of construction occur, both lines will be prescribed. Harbor lines are usually straight line-segments crossing the outermost pierheads and/or bulkhead facilities, and are marked with accurately located, permanent monuments so that local surveyors may easily locate them.

HARBOR OF REFUGE

A harbor provided as a temporary refuge on a stormy coast for the convenience of passing shipping. It may or may not be part of a shipping port. Also called port of refuge. HDAPS Stands for Hydrographic Data Acquisition and Processing System. Antiquated hydrographic acquisition and processing software used during the late 1980s and obsolete by the mid-1990s.

HDOP (HORIZONTAL DILUTION OF PRECISION)

The horizontal dilution of precision (HDOP) allows one to more precisely estimate the accuracy of GPS horizontal (latitude/longitude) position fixes by adjusting the error estimates according to the geometry of the satellites used. In probability terminology, HDOP is an additional variable that allows one to replace the overall accuracy estimates with conditional accuracy for the given HDOP value.

HEAD

A steep cape or peninsula.

HEADING

The horizontal direction in which a ship actually points or heads at any instant, expressed in angular units from a reference direction, usually from 000° at the reference direction clockwise through 360°. Heading is often designated as true, magnetic, compass, or grid, as the reference direction is true, magnetic, compass, or grid north, respectively. Heading should not be confused with course, which is the intended direction of movement through the water. At a specific instant the heading may or may not coincide with the course, depending upon such factors as steering errors, actions of the seas upon the ship, etc. The heading of a ship is also called Ship's Head.

HEADLAND

1. In common usage, a land mass having a considerable elevation. In the context of the Law of the Sea, elevation is not an important attribute and a headland may be the apex of a salient of the coast, the point of maximum extension of a portion of the land into the water, or a point on the shore at which there is an appreciable change in direction of the general trend of the coast. 2. A geographic feature that serves to give an inland water body its landlocked nature. A headland may be natural or man-made. It must be above mean low water but not by any significant extent. It will usually provide an appreciable change in the direction of the coast.

HEAVE

The oscillatory rise and fall of a ship due to the entire hull being lifted by the force of the sea. The disjointed, jagged images on a sonar record produced by heave. Heave is a major cause of data distortion. Heave compensators are used on vessels to remove the effect of this motion from the recorded seabed profile. Also applies to the rhythmic up and down movement of a towfish in moderate to heavy seas. Under some conditions, longer tow cables will dampen the effect of heave affecting towfish but can also result in a harmonic effect, increasing the heave.

HIGH SEAS

The open sea beyond the Exclusive Economic Zone, the territorial sea or the archipelagic waters of an archipelagic country.

HIGH WATER

The maximum height reached by a rising tide. The high water is caused by the periodic tidal forces and the effects of meteorological, hydrologic, and/or oceanographic conditions. For tidal datum computational purposes, the maximum height is not considered a high water unless it contains a tidal high water.

HIGH WATER LINE

1. The intersection of the land with the water surface at an elevation of high water. 2. A generalized term associated with the tidal plane of high water, but not with a specific phase of high water, such as higher high water or lower high water.

HIGH WATER MARK

A line or mark left upon tide flats, beach, or alongshore objects indicating the elevation of the intrusion of high water. The mark may be a line of oil or scum on alongshore objects, or a more or less continuous deposit of fine shell or debris on the foreshore or berm. This mark is physical evidence of the general height reached by wave runup at recent high waters. It should not be confused with the mean high water line or mean higher high water line.

HIPS VESSEL FILE (HVF)

A file generated in CARIS software used to set the parameters for sensors and other equipment for data processing. Previously referred to as a Vessel Configuration File (VCF).

HISTORY SHEET

See Chart History.

HOLDING GROUND

An expression usually used with a modifying adjective to indicate the quality of the holding power of the material constituting the bottom of an anchorage; e.g., of good (or poor) holding power.

HOLIDAY

An unintentionally unsurveyed area within a given hydrographic survey project, where the spacing between soundings, sounding lines, or surveys exceeds the maximum allowable limits.

HOOK

Something resembling a hook in shape, particularly (a) a spit or narrow cape of sand or gravel which turns landward at the outer end, or (b) a sharp bend or curve, as in a stream.

HORIZONTAL BEAM WIDTH

The angle of the transmitted (and/or received) sonar beam in the along-track (transverse) dimension. Narrow horizontal beamwidths increase transverse resolution. Because beamwidth is related to transducer length and frequency, beamwidth decreases with increasing frequency for a given transducer length.

HORIZONTAL CONTROL

Historically, a network of stations of known geographic or grid positions referred to a common horizontal datum, which control the horizontal position of mapped features with respect to parallel and meridians, or northing and easting grid lines shown on the map. Horizontal control includes basic (marked) and supplementary (unmarked) stations.

HORIZONTAL CONTROL STATION

A station whose position has been accurately determined in x and y grid coordinates, or latitude and longitude. Also called horizontal control point.

HORIZONTAL DATUM

1. At its most basic level of definition, the horizontal datum is a collection of specific points on the Earth that have been identified according to their precise northerly or southerly location (latitude), and their easterly or westerly location (longitude). 2. A reference system for specifying positions on the Earth's surface. Each datum is associated with a particular reference spheroid that can be different in size, orientation, and relative position from the spheroids associated with other horizontal datums. Positions referred to different datums can differ by several hundred meters.

HPS

Stands for Hydrographic Processing System. Outdated proprietary NOAA hydrographic data processing software.

HULK

The hull or portion of the hull of a derelict vessel, usually without superstructure or other appurtenance. A major portion of the hulk is usually visible at some stage of tide.

HYDRO HOT LIST

A list, maintained by CO-OPS, of water level stations which are currently providing data for NOAA hydrographic surveys. If a station is on the Hydro Hot List, the gauge's data is carefully monitored and its processing is given priority over other gauges.

HYDRODYNAMIC DEPRESSOR

A tow assembly depressor designed with vanes or a wing oriented in such a way as to increase negative lift when exposed to an increased water flow. Hydrodynamic depressors work by increasing the downward pull on the towbody end of the cable during towing. The advantage of this kind of depressor is that they are lightweight and relatively easy to deploy. Some types can be rigged to invert and increase drag if they come in contact with the seabed, thus rapidly bringing the towfish to altitude and out of collision danger. They must be rigged carefully so as to be tangle-free during and after deployment. A disadvantage to the hydrodynamic depressor is that an increase in towspeed will not raise the towfish to avoid an obstruction. It may, instead, bring it deeper. Another disadvantage to this type of depressor is that it typically requires significant towspeeds to develop effectiveness.

HYDROGRAPHER

One who studies and practices the science of hydrography. The term is capitalized when referring to the person in charge of a hydrographic department or office of a country.

HYDROGRAPHIC DATA CLEANING SYSTEM (HDCS)

CARIS's acronym for their Hydrographic Data Cleaning System. The HDCS data format uses the Project/Vessel/Day/Line (PVDL) hierarchical structure to store the information.

HYDROGRAPHIC MANUALS

The form of publication used by NOAA since 1928 for providing instructions for hydrographic work. Four such manuals have been issued to date – in 1928, 1942, 1960, and 1976.

HYDROGRAPHIC SURVEY

A survey having for its principal purpose the acquisition of data relating to a body of water for the purpose of promoting safe navigation. A hydrographic survey may consist of or require one or several of the following classes of data: depth of water; configuration and nature of the bottom; velocity of currents; heights and times of tides and water levels; location of aids and dangers to navigation; configuration of marginal land areas; and determination of magnetic declination and anomalies for navigating by magnetic compass. Information on geographic names and harbor facilities may also be documented.

HYDROGRAPHIC SURVEY EXAMINATION

Consequent to a formal policy transferring responsibility for hydrographic survey quality and final approval to the then Office of Marine Operations, the quality control of all hydrographic survey products was discontinued in October, 1982. Instead, procedures and policies were established to conduct quality control examinations on a statistically representative sample consisting of not more than 10% of products. This examination was identified as a Hydrographic Survey Examination and was approximately equivalent to the preparation of a Quality Control Report. However, it differed from the quality control examination in that the effort was directed toward evaluating compliance with, and the adequacy of, standards, rather than a careful examination of the data and their quality. Each survey selected was carefully examined by a cartographer for adequacy with respect to data acquisition and conformance with applicable standards and project instructions. In addition, the overall condition of the records and the descriptive report were reviewed. The digital data representing the survey was plotted and subjected to a cursory examination to determine the degree of compliance with digital data standards. The examination was limited to only that necessary to evaluate the acquisition and processing procedures.

HYDROGRAPHIC SURVEY GUIDELINES

A discontinued series of guidelines initiated in 1979 to emphasize, interpret, and supplement material contained in the NOAA Hydrographic Manual, Fourth Edition, and various other publications and memorandums. The Guidelines were intended primarily for communication of processing techniques between the Hydrographic Surveys Division and the Marine Centers.

HYDROGRAPHIC SURVEY SHEET

An inclusive term used to designate boat sheets, field sheets, and smooth sheets.

HYDROGRAPHY

The branch of applied science which deals with the measurement and description of the physical features of the navigable portion of the Earth’s surface and adjoining coastal areas, with special reference to their use for the purpose of navigation.

HYDROPHONE

A sonar receiver functioning by transforming underwater sound signals (pressure waves) into electrical signals. Often a hydrophone is a passive device doing no transmitting on its own.

HYPERBOLIC POSITIONING SYSTEM

A positioning system in which the observer measures the difference in time of reception of signals from two stations whose coordinates are known. The difference in time is converted to a difference in distance. The locus of all points lying at a fixed difference in distance from two points are the two branches of a hyperbola. There is usually a third station operating in conjunction with one of the two to provide the observer with another difference in distance and another pair of hyperbola branches. The observer is at one of the intersections of the branches. LORAN is the oldest known positioning system using this technique.

7.9 I

IDENTIFICATION LETTERS AND NUMBERS

Letters and numbers (in color) once used to identify sounding lines on a hydrographic survey sheet and which correspond to those used in the sounding records.

IHB

See International Hydrographic Bureau.

IHO

See International Hydrographic Organization.

IKONOS

The Ikonos-2 satellite was launched in September, 1999, and has been delivering commercial data since early 2000. Ikonos is the first of the next generation of high spatial resolution satellites. Ikonos data records 4 channels of multi-spectral data at 4 m resolution, and 1 panchromatic channel with 1 m resolution. This means that Ikonos was the first private-sector satellite to deliver near-photographic high-resolution satellite imagery of objects or specified locations anywhere in the world, e.g., shorelines. Ikonos-2 is equipped with a Kodak digital camera. This payload will enable the satellite to collect 1-m resolution panchromatic (gray-scale) resolution and 4-m resolution, 4-band multi-spectral (red, green, blue, near infrared) imagery of the Earth. The camera is comprised of a Kodak-designed and -manufactured focal plane array and a lightweight telescope using a state-of-the-art mirror fabricated with Kodak's advanced ion-figuring technology. To speed the downloading of data to Space Imaging EOSAT's ground receiving stations, the original 11-bit data will be compressed using Kodak's proprietary bandwidth compression technology.

IMPROVED CHANNELS

Dredged channels under the jurisdiction of the U.S. Army Corps of Engineers, and maintained to provide an assigned controlling depth. Symbolized on the nautical/navigational charts by black, dashed lines to represent the side limits, with the controlling depth and date of ascertainment; sometimes accompanied by a tabulation for more detailed information.

INERTIAL POSITIONING SYSTEM

A positioning system consisting of a computer and an assemblage of three accelerometers and two or three gyroscopes. The gyroscopes are fastened together in such a way that they define the orientation of the accelerometers with respect to non-rotating coordinates and the accelerometers measure the components of acceleration of the positioning system along the directions defined by the gyroscopes. The computer and associated equipment integrate the components of acceleration to give the 3 components of displacement of the positioning system.

INFORMATION AWOIS ITEM

An AWOIS item for which no search radius has been assigned. If the item is detected in the course of hydrography, develop to fullest extent.

INLAND RULES OF THE ROAD

Rules to be followed by all vessels while navigating upon certain inland waters of the U.S. See also Colregs.

INLAND WATER LINE

A series of straight lines developed by the Coast Guard to separate areas that are subject to its Inland Rules of the Road from those to which the International Rules apply. The lines have no bearing on inland water determinations for Convention of Submerged Lands Act purposes.

INLAND WATERS

Waters landward of the baseline from which the marginal seas are measured and over which complete sovereignty is exercised. Specific information is contained within 33 U.S.C. Chapter 3. Also known as “internal waters.”

INLET

1. A narrow strip of water running into the land or between islands. 2. An arm of the sea (or other body of water) that is long compared to its width, and that may extend a considerable distance inland.

INNER HARBOR

The part of a harbor more remote from the sea, as contrasted with the outer harbor. These expressions are usually used only in a harbor that is clearly divided into two parts, as by a narrow passageway or man-made structures. The inner harbor generally has additional protection and is often the principal berthing area.

INS

See Integrated Navigation System.

INSET

In cartography: (a) a small area outside the neat lines of a map or chart included within the neat lines or borders to avoid publishing a separate graphic of the small area alone; (b) a representation of a small area on a larger scale (e.g., town-plan inset), or of a large area at a smaller scale (e.g., orientation inset); (c) any information, not normally appearing within the geographic limits of a map, which has been enclosed by border lines and included within the map neat lines. Insets are always placed in areas where important features will not be covered. See Subplan.

INSHORE

1. In beach terminology, the zone of varying width extending from the low water line through the breaker zone. 2. In NOAA operational hydrography terminology, the zone extending shoreward from depths of 8 m.

INTEGRATED NAVIGATION SYSTEM

Most commonly, a computer-based navigation system deployed on large vessels. INS systems have one or more displays and take input from a navigational device such as a GPS receiver and display the ship’s track, course, and heading on a screen. Modern units allow the user to log targets, filter errant position fixes, log the ship’s position history, display user-defined lines the ship is to follow, and display shorelines.

INTERFERENCE

The display of erroneous signals from acoustic or electrical sources that conflict with the display of the primary sonar data. Interference can be internal to the sonar system, but is most commonly from other sources. Causes of external interference include generator noise, electromagnetic radiation from other electronics, ship’s engines and propellers, flow noise, and noise from biological sources. See Noise.

INTERFEROMETRIC SONAR

A system based on the process by which two or more sonar waves of the same frequency combine to reinforce or cancel each other, the amplitude of the resulting wave being equal to the sum of the amplitudes of each of the combining waves. Because the angle of interference can be determined, these sonar systems provide bathymetric information over a wide swath.

INTERNATIONAL CHART

One of a coordinated series of small-scale charts for planning and long range navigation. The charts are prepared and published by different Member States of the International Hydrographic Organization (IHO) using the same specifications.

INTERNATIONAL GREAT LAKES DATUM 1985 (IGLD)

A vertical control datum having its zero horizontal plane at mean sea level at Rimouski, Quebec, as determined from measurements at Rimouski/Pointe-au-Pere over the period 1982-1988. It is used primarily for the definition of the chart datum, Low Water Datum, in each of the Great Lakes, their connecting waterways, and the St. Lawrence River, and for hydraulic studies of the same. IGLD (1985) was implemented, effective January 1992, replacing the old International Great Lakes Datum (1955).

INTERNATIONAL HYDROGRAPHIC BUREAU (IHB)

An organization founded in 1921 for the purpose of establishing a close and permanent association among hydrographic offices of its 19 Member States. The Bureau was provided with headquarters in the Principality of Monaco by H.S.H. Prince Albert I of Monaco, a noted marine scientist. In 1970, an intergovernmental Convention entered into force which changed the organization's name and legal status, creating the International Hydrographic Organization (IHO), with its headquarters (the IHB) permanently established in Monaco.

INTERNATIONAL HYDROGRAPHIC ORGANIZATION (IHO)

An intergovernmental consultative and technical organization that traces its origin to 1921 and was established to support safety in marine navigation and the protection of the marine environment. The main objectives of the IHO is to bring about the coordination of the activities of national hydrographic offices, the greatest possible uniformity in nautical charts and documents, the adoption of reliable and efficient methods of carrying out and exploiting hydrographic surveys, the development of the sciences in the field of hydrography and the techniques employed in descriptive oceanography.

INTERNATIONAL NAUTICAL MILE

In 1929, the International Hydrographic Conference in Monaco defined the international nautical mile as exactly 1,852 m, about 6,076.11549 ft.

INTRACOASTAL WATERWAY

An approximately 3,000 mile-long, partly natural, partly artificial, waterway, providing sheltered passage for commercial and leisure boats along the U.S. Atlantic coast from Boston, MA to Key West, in southern FL, and along the Gulf of Mexico coast from Apalachee Bay, in NW FL, to Brownsville, TX, on the Rio Grande. The toll-free waterway, authorized by Congress in 1919, is maintained by the U.S. Army Corps of Engineers at a minimum depth of 12 ft (4 m) for most of its length; some parts have 7-ft (2.1-m) and 9-ft (2.7-m) minimum depths. The Intracoastal Waterway has a good deal of commercial activity; barges haul petroleum, petroleum products, foodstuffs, building materials, and manufactured goods. [From: The Columbia Encyclopedia, Sixth Edition. Copyright © 2003, Columbia University Press., NY, NY]

ISLAND

In agency usage, a land area (smaller than a continent) extending above and completely surrounded by water at mean high water; an area of dry land entirely surrounded by water or a swamp; an area of swamp entirely surrounded by open water.

ISLET

A small island.

ISTHMUS

A narrow strip of land connecting two larger bodies of land.

7.10 J

JETTY

A substantial, artificial structure erected on the coast for the purpose of extending the flow of a river or protecting a harbor or beach.

JULIAN DAY

The consecutive number of each day commencing January 1, 4713 B.C. The Julian day begins at noon, 12 hours later than the corresponding civil day. For example, the day beginning at noon January 1, 1968 was Julian day 2,439,857. This term is often incorrectly used when referring to the sequential 3-digit day number of the year. The sequential 3-digit day number of the year should be referred to as the “day of year” or “day number” rather than as the “Julian Day.”

JUNCTION

A place of meeting or joining. In hydrographic surveying, the joining of two or more adjacent/adjoining survey sheets.

JUNCTION BUOY

A buoy which, when viewed from a vessel approaching from the open sea or in the same direction as the main stream of flood current, or in the direction established by appropriate authority, indicates the place at which two channels meet. Also referred to as a Bifurcation Buoy.

7.11 K

KAPP

A unique number assigned to each chart panel, inset, or extension of all agency nautical charts. See Chapp.

KELP

An order of usually large blade-shaped or vine-like brown algae that grows on rocky bottoms and is therefore associated with possible dangers to navigation.

KEY

See Cay.

KINEMATIC SURVEYING

Kinematic surveying is a method of surveying with GPS that initially solves wavelength ambiguities and retains the resulting measurements by maintaining a lock on a specific number of satellites throughout an entire surveying period. Observations are made while a receiver is in motion. In surveying applications, kinematic refers to uninterrupted carrier-phase measurements following successful solution of the integer ambiguities. This can be accomplished in a continuous mode where the receiver remains in motion for precise positioning of a vehicle, or in an intermittent mode where data is recorded only after a receiver is brought to a stationary point, and the observations while in motion are tracked as a way to maintain the integer ambiguities.

KITING

A rhythmic, lateral movement experienced by tow bodies on long cables and in deep water; most often induced by poor hydrodynamics of a depressor. The proper application of depressors is important to maintain reliable fish stability. One depressor shape and form may work well at only certain speeds, while creating instabilities at others. Kiting is one of a variety of instabilities that can be recognized in sonar data.

KNOT

A unit of speed defined (1978) as 1 international nautical mile per hour. It was previously defined as 1 nautical mile per hour, but this led to confusion because the American and British nautical miles differ by 1.184 m. The knot is equal to 1.852 km/hr.

7.12 L

LAGOON

A shallow body of water which usually has a shallow restricted inlet from the sea.

LAKE

Any standing body of inland water, generally of considerable size. There are exceptions, such as the lakes in Louisiana which are open to or connect with the Gulf of Mexico. Occasionally, a lake is called a sea, especially if very large and composed of salt water.

LAMBERT CONFORMAL CONIC PROJECTION

A conformal map projection of the conical type, on which the meridians are straight lines meeting in a common point outside the limits of the map, and the parallels are concentric arcs of circles having the common point as center.

LAND

The solid part of the surface of the earth, as opposed to water as constituting a part of such surface.

LANDING

A place where boats receive or discharge passengers, freight, etc.

LANDMARK

A conspicuous object, natural or man-made, located near or on land, which aids in fixing the position of an observer.

LARGE NAVIGATIONAL BUOY (LNB)

A large buoy designed to take the place of a lightship, where construction of an offshore light station is not feasible. These 40-ft diameter buoys may show secondary lights from heights of about 36 ft above the water. In addition to the light, such buoys may mount a radiobeacon and provide sound signals. A station buoy may be moored nearby.

LARGE SCALE SURVEY (CHART)

A scale involving a relatively small reduction in size. A large scale chart is one covering a small area. The opposite is small scale. In agency usage, a scale of 1:80,000 would be the upper limit of classification.

LATERAL OFFSET

The position of the towfish off to the side of the surface vessel's track. This occurs when the surface vessel track is not aligned with a surface or subsea current. It can also be caused by poor hydrodynamics. The effect of the current will pull the towfish away from the vessel trackline. In extreme cases, the towfish can also crab into such a current and result in a loss of data.

LATERAL SYSTEM

A system of aids to navigation in which buoys, daybeacons, and minor lights are assigned colors and shapes in accordance with their respective location in relation to safe water.

LATTICE

A pattern formed by two or more families of intersecting lines, such as the pattern formed by two or more families of hyperbolas representing curves of equal time difference associated with a hyperbolic radio navigation system. Sometimes the term “pattern” is used to indicate curves of equal time difference, with the term “lattice” being used to indicate its representation on the chart.

LATITUDE

Angular distance from a Primary Great Circle or plane, usually the Equator. One of the coordinates used to describe a position, the other being longitude.

LAW OF THE SEA CONVENTION

The United Nations’ 1982 Convention that, for most purposes, supersedes the four Geneva Conventions of 1958. The “baseline” provisions of the Law of the Sea Convention do not deviate significantly from those of the Convention on the Territorial Sea and the Contiguous Zone. The Supreme Court’s adoption of the 1958 principles for purposes of the Submerged Lands Act is not affected by the new Convention. Entered into force on November 16, 1994. The United States has recognized most provisions of the 1982 Convention as customary international law (including the baseline provisions).

LAYBACK

The horizontal distance between the survey vessel, or the navigation antenna, and the towfish. In deep water towing, this distance is important for positioning features on the seabed and geo-coding sonar data for mosaics. Because most navigation instruments provide the position of their antenna mounted on the vessel and the “x, y” origin of the sonar image is at the towfish, this difference in position can be significant. Many methods of subtracting this distance have been tested using acoustics and algorithms. Acoustic fish positioning methods rarely work well and often cause more problems than they solve. Algorithms, while not calculating such parameters as lateral offset, are very accurate in eliminating layback errors.

LEAD

A weight attached to a line. A sounding lead is used for determining depth of water. A hand lead is a light sounding lead (7 - 14 lbs), usually having a line of not more than 25 fm. A deep sea lead is a heavy sounding lead (about 30 - 100 lbs), usually having a line 100 fm or more in length. A light deep sea lead (30 - 50 lbs), used for sounding depths of 20 - 60 fm, is called a coasting lead. A type of sounding lead used without removal from the water between soundings is called a fish lead. A drift lead is one placed on the bottom to indicate movement of a vessel. To heave the lead is to take a sounding with a lead.

LEAD LINE

A line, graduated with attached marks and fastened to a sounding lead, used for determining the depth of water when taking soundings by hand. The lead line is usually used in depths of less than 25 fm. Also called a sounding line.

LEAGUE

A measure of distance, varying for different times and for different countries, from 2.4 - 4.6

miles. In the U.S. it is considered to be about three miles.

LEAST DEPTH

The minimum depth of a submerged feature. The term is only used when the quality of the sounding meets existing hydrographic accuracy standards. It is never considered to be an approximate depth.

LEDGE

A rocky formation connected with and fringing the shore, and generally uncovered at the sounding datum. Where such features exist, the seaward limit of the area that uncovers is usually symbolized on smooth sheets and serves as a substitute for the zero depth curve.

LEEWARD

The direction toward which the prevailing wind is blowing; the direction toward which waves are traveling.

LEFT BANK

The river bank on the left-hand side as one proceeds downstream.

LEGEND

A description, explanation, table of symbols, and other information, printed on a map or chart to provide a better understanding and interpretation of it. The title of a map or chart formerly was considered part of the legend, but this usage is obsolete.

LEVEE

1. An artificial or naturally formed low ridge of material built or deposited along a stream channel or limit areas subject to flooding. 2. An embankment bordering on one or both sides of a submarine canyon or sea channel, usually occurring along the outer edge of a curve or meander. See Dike, often incorrectly used interchangeably with levee.

LEVELING

The process of determining differences of elevation between points on the surface of the earth; the determination of the elevation of points relative to a vertical datum. Also called differential leveling.

LIDAR (LIght Detection and Ranging)

An airborne instrument that measures distance to an object by emitting timed pulses of light and measuring the time between emission and reception of the reflected pulses. The measured time interval is converted into distance. Topographic LIDAR measures elevations on land. Bathymetric LIDAR uses two different laser frequencies to measure water depths (one reflects of the water surface and the other off the seafloor). The ability of bathymetric LIDAR to obtain such depth information is totally dependent on water turbidity but can measure depths of 60 meters in very clear water.

LIGHT

A luminous or lighted aid to navigation.

LIGHTHOUSE

A building on some conspicuous point of the coast, a pier or jetty, an island or rock, from which a light is exhibited at night as an aid to navigation. All maritime nations have government departments responsible for the establishment and maintenance of lighthouses.

LIGHT LIST

A publication that lists and describes all marine aids to navigation maintained by or under authority of the U.S. Coast Guard.

LIGHT LIST NUMBER

The number used to identify a navigational light in the Light List.

LIGHT SECTOR

As defined by bearings from seaward, the sector in which a navigational light is visible or in which it has a distinctive color different from that of adjoining sectors, or in which it is obscured.

LINE

A course or track, down the center of which a survey vessel travels during a survey. A line is delineated on either side by half the distance between the current and adjacent tracks. A common method of using sonar to perform search or survey operations is to set up a series of parallel lines. Represented as imaginary lines on the sea surface, they may be depicted on a computer screen from an Integrated Navigation System.

LINEAR SCALE

Known in the U.S. as a bar scale. A sub-divided line which shows distances at a given scale. See also Graphic Scale.

LINE FEATURE

A cartographic feature with the geometry of a line, i.e., defined by a sequence of connected points. Represented on a map by a line of a certain width or type, e.g., dashed, dotted, double, a sequence of symbols. Contrast with point feature and area feature.

LINE SMOOTHING

The numerical manipulation of data points (pairs of coordinates) in order to reduce the number or amount of undulations along a line. May be used to remove irregularities introduced during digitizing, e.g., in case of line segments which do not join exactly or smoothly enough.

LINE SPACING

The distance between successive parallel vessel tracks in a multi-line survey that are traversed to build a grid to cover an intended survey area. Line spacing will vary depending upon survey equipment and operational goals.

LITTORAL

Of, or pertaining to, a shore, especially a seashore. Specifically, the various parts of a region bordering the sea, including the coast, foreshore, backshore, beach, etc.

LOCAL NOTICE TO MARINERS (LNM)

A notification issued at frequent intervals by U.S. Coast Guard districts giving changes and deficiencies in aids to navigation and other information of navigational importance within the particular district. LNM was historically a printed document, but is now available only on the U.S. Coast Guard website. Information of a continuing nature is included in the weekly Notice to Mariners which is issued by NGA.

LOCK

A basin in a waterway with caissons or gates at each end by means of which vessels are passed from one water level to another without materially affecting the higher level. To lock a vessel means to pass a vessel through a lock.

LOG BOOM

A floating barrier of timber used to protect a river or harbor mouth or to create an enclosed area for storage purposes.

LONGITUDE

Angular distance, along a Primary Great Circle, from the adopted reference point, usually the Greenwich or prime meridian. One of the coordinates used to describe a position, the other being latitude.

LORAN

A navigation system developed in the 1950s based on the time displacement between signals from two or more fixed shore based antennas. Two types of LORAN (an acronym for LOng RAnge Navigation) were developed. A low resolution LORAN-A was first. Cumbersome and difficult to use, LORAN-A required the user to tune a receiver and align signal peaks on a scope. A more efficient system, LORAN-C, was developed for use in the 1960s and provided the user with a readout of numbers representing time differences in microseconds. American charts were produced with these "TD" lines overprinted on them. Although LORAN-C was very repeatable (often to within 20 m), the system was not accurately tied to any datum. Further, since the radio transmissions propagated over land, conversion to latitude and longitude was only approximate, at best. For several decades since the late 1950s, LORAN was the major worldwide land-based navigation system. Offshore beyond the 600-mile range of these systems, dead reckoning with occasional fixes from transit satellites was a large part of ocean navigation. The Global Positioning System is expected to completely replace the need for LORAN transmitting stations worldwide.

LOW ORDER STATIONS

A category of control established by ground survey methods that do not meet established Third-Order criteria. Included are stations positioned through the use of a sextant or planetable, and any station positioned from, or sighting on, a moving object such that repeat measurements cannot be made.

LOWER LOW WATER (LLW)

The lowest of the low waters (or single low water) of any specified tidal day due to the declinational effects of the Moon and Sun.

LOW-TIDE ELEVATION

A naturally formed area of land surrounded by and above water at low tide but submerged at high tide. Low-tide elevations serve as part of the coast line when they are within the breadth of the territorial sea of the mainland or an island.

LOW WATER

The minimum height reached by a falling tide. The low water is due to the periodic tidal forces and the effects of meteorological, hydrologic, and/or oceanographic conditions.

LOW WATER DATUM (LWD)

An approximation of mean low water that has been adopted as a standard reference for a limited area and is retained for an indefinite period regardless of the fact that is may differ slightly from a better determination of mean low water from a subsequent series of observations. Used primarily for river and harbor engineering purposes.

LOW WATER LINE

The intersection of the land with the water surface at an elevation of low water.

7.13 M

MAGNETIC ANOMALY

The difference between the intensity of the magnetic field at a particular place and the intensity predicted for that place by a standard formula, such as that for a magnetic dipole.

MAGNETIC BEARING

Bearing determined with a magnetic compass and related to the magnetic meridian.

MAGNETIC NORTH

The direction indicated by the north-seeking pole of a freely suspended magnetic needle, influenced only by the earth's magnetic field.

MAGNETIC POLE

Either of the two places on the surface of the Earth where the magnetic dip is 90 degrees, that in the northern hemisphere being designated north magnetic pole, and that in the southern hemisphere being designated south magnetic pole. The magnetic poles are not fixed and do not coincide with the geographical poles.

MAGNETIC VARIATION

The angle between the magnetic and geographical meridians at any place, expressed in degrees east or west to indicate the direction of magnetic north from true north. Also called magnetic declination.

MAINLAND

The principal portion of a large land area. The term is used loosely to contrast a principal land mass from outlying islands and sometimes peninsulas.

MAINSCHEME

A term used to describe the primary set of sounding lines in a hydrographic survey.

MAJOR AID TO NAVIGATION

An aid of considerable intensity, reliability, and range exhibited from fixed structures or marine sites. Major aids are classified as primary or secondary and are usually manned or remotely monitored.

MANGROVE

For charting purposes, includes the mangroves and stands of tree-like plants that are predominately mangrove. These plants are perennials that frequently create an apparent shoreline. Much of this vegetation grows in the vicinity of the high waterline with overhanging and tangled growth that obscures the shoreline. Mangrove is found in saltwater throughout the tropics.

MAN-MADE SHORELINE

The line of contact between the surface of a body of water and man-made land or features provided the man-made waterline is continuous with the natural shoreline. This is intended to include as man-made shoreline the water line along breakwaters, bulkheads, fill areas, jetties, and other features built out from the land.

MANUSCRIPT

The original hand drawing of a map as compiled or constructed from various data, such as ground surveys, photographs, etc.

MAP

A graphic representation of the physical features of the earth's surface observed during one or more surveys and depicted on a definite projection.

MAP LOCATION

The location of a point or line on a map, rather than its demarcation on the ground.

MAP PROJECTION

The process by which a portion or all of the curved surface of the earth can be represented on a plane with the least amount of distortion; a systematic drawing of lines representing meridians and parallels on a plane surface, either for the whole earth or some portion of it. See Projection.

MARGINAL SEA

See Territorial Sea.

MARIGRAM

Agraphic record of the rise and fall of the tide. The record is in the form of a curve in which time is generally represented on the abscissa and the height of the tide on the ordinate.

MARINA

A harbor facility for small boats, yachts, etc., where supplies, repairs, and various services are available.

MARINE RAILWAY

A track, cradle, and winching mechanism for hauling vessels out of the water so that the bottom can be exposed, as in a dry dock.

MARK

1. A charted conspicuous object, structure, or light serving as an indicator for guidance or warning of a water craft. 2. A definite object (such as an imprinted metal disk) used to designate a survey point and usually used with a qualifying term such as “Reference Mark” or “Bench Mark”. 3. A call used by hydrographers to signal an event such as the instant a survey position is recorded.

MARKER

That which marks something for a specific purpose, e.g., a measured mile marker, or a dredging range marker. This term is generally used to refer to certain aids to navigation, often privately maintained, which are erected to mark channels.

MARKER BUOY

A buoy used to temporarily mark a location of particular interest, such as a shoal, reef, obstruction, or diving operation.

MARSH

A tract of soft, wet land, usually vegetated by reeds, grasses and occasionally small shrubs.

MEADES RANCH

A triangulation station established in 1891 in central Kansas which was adopted as the basis for the United States Standard Datum. The selection was based on the fact that it was near the center of area of the United States and was common to 2 great arcs of triangulation extending across the country – one along the 39th parallel and the other along the 98th meridian. The origin or initial point for the North American Datum of 1927 (NAD 27) which was the regional horizontal coordinate system used throughout the U.S. until 1986.

MEAN HIGHER HIGH WATER (MHHW)

A tidal datum which is the average of the higher high water heights of each tidal day observed over a 19-year National Tidal Datum Epoch. For stations with shorter series, simultaneous observational comparisons are made with a control tide station in order to derive the equivalent datum of the National Tidal Datum Epoch.

MEAN HIGH WATER (MHW)

A tidal datum which is the average of all the high water heights of each tidal day observed over a 19-year National Tidal Datum Epoch. For stations with shorter series, simultaneous observational comparisons are made with a control tide station in order to derive the equivalent datum of the National Tidal Datum Epoch

MEAN LOWER LOW WATER (MLLW)

A tidal datum which is the average of the lower low water heights of each tidal day observed over a 19-year National Tidal Datum Epoch. For stations with shorter series, simultaneous observational comparisons are made with a control tide station in order to derive the equivalent datum of the National Tidal Datum Epoch

MEAN LOW WATER (MLW)

A tidal datum which is the average of all the low water heights of each tidal day observed over a 19-year National Tidal Datum Epoch. For stations with shorter series, simultaneous observational comparisons are made with a control tide station in order to derive the equivalent datum of the National Tidal Datum Epoch

MEAN SEA LEVEL (MSL)

A tidal datum that is the arithmetic mean of hourly water elevations observed over a 19-year National Tidal Datum Epoch. Shorter series are specified in the name; e.g., monthly mean sea level and yearly mean sea level.

MEAN WATER LEVEL

A tidal datum which is the mean surface elevation as determined by averaging the heights of the water at equal intervals of time, usually hourly, over a 19-year National Tidal Datum Epoch. Mean water level used in areas of little or no range in tide.

MEASURED MILE

An cartographically displayed length of 1 nautical mile, the limits of which have been accurately measured and are indicated by ranges ashore. It is used by vessels to calibrate logs and engine revolution counters, and to determine speed.

MERCATOR CHART

A chart on the Mercator Projection. This is the chart commonly used for marine navigation. On a Mercator chart, a rhumb line is a straight line.

MERCATOR PROJECTION

A Conformal Projection of the cylindrical type. The Equator is represented by a straight line true to scale; the geographic meridians are represented by parallel straight lines perpendicular to the line representing the Equator; they are spaced according to their distance apart at the Equator. The geographic parallels are represented by a second system of straight lines perpendicular to the family of lines representing the meridians, and therefore parallel with the Equator. Conformality is achieved by mathematical analysis, the spacing of the parallels being increased with the increasing distance from the Equator to conform with the expanding scale along the parallels resulting from the meridians being represented by parallel lines. Since Rhumb Lines appear as straight lines and directions can be measured directly, this projection is widely used in navigation.

MERIDIAN LINE

A north-south line from which longitudes or azimuths are reckoned.

MERIDIANS

A north-south reference line, particularly a great circle through the geographical poles of the earth. Meridians are measured in degrees east or west of the prime meridian and pass through longitude 0°. See Longitude.

MERIDIONAL PARTS

The length of the arc, expressed in units of 1 min of longitude at the equator, of a meridian between the Equator and any parallel of latitude on the graticule of the Mercator map projection. See Tables for a Polyconic Projection of Maps.

METES AND BOUNDS

The boundary lines or limits of a tract of land. One of the oldest methods of describing land and was used to transfer lands in the Thirteen Original Colonies. Defined variously in law dictionaries as: the boundary lines of land, with their terminal points and angles; the boundary lines and corners of a piece of land; and the boundary lines of lands with their terminating points of angles.

MILE

A unit of distance. The nautical mile, or sea mile, is used primarily in navigation. Nearly all maritime nations have adopted the International Nautical Mile of 1,852 m proposed in 1929 by the International Hydrographic Bureau. The International Nautical Mile is equivalent to 6076.11549 ft, approximately. The geographical mile is the length of 1 minute of arc of the equator, considered to be 6,087.08 ft. The statute mile or land mile (5,280 ft in the U.S.) is commonly used for navigation on rivers and lakes, notably the Great Lakes of North America.

MILEAGE NUMBER

Assigned to aids and gives the distance in sailing miles along the river from a reference point to the aid. Principally used in the Mississippi River System.

MINIMUM OBSERVED DEPTH

The shallowest depth over a submerged feature obtained during the course of a non-specific investigation. It may not be the Least Depth but could be reclassified as such following a careful review of the data to determine if it meets or exceeds current specifications for a basic hydrographic survey.

MICRO WAVE POSITIONING SYSTEM

A compact, light, and mobile distance measuring system that operates on the basic principle of pulse radar. A transmitter aboard the survey vessel interrogates transponders at known locations. Elapsed time between transmitted interrogations and the reply from each transponder is used as the basis for determining range to each transponder. This range information, together with the known location of each transponder, can be trilaterated to provide the position of the survey vessel. A widely used type of survey positioning system in the 1970's through early 1990's which was made obsolete by GPS.

MINOR AID TO NAVIGATION

An unmanned, unmonitored light on a fixed structure showing usually low to moderate intensity; generally fitted with light characteristics and day boards in accordance with its lateral significance in the waterway.

MINUS SOUNDINGS

Soundings that reduce to height above the sounding datum (plane of reference) when corrected for water level. Minus soundings are shown on the smooth sheet preceded by a minus sign unless they are used to denote the least depth on a wreck or obstruction. In that case, the sounding is portrayed as an underlined value in parentheses. A minus sounding has a value above chart datum. For example, chart datum of MLLW would be the 0 contour; a value of -1 would be 1 ft above MLLW chart datum water line.

MISCELLANEOUS SOURCES

Source information provided by other organizations. Such sources would include the U.S.

Army Corps of Engineers, U.S. Coast Guard, National Geospatial-Intelligence Agency (formerly known as the National Imagery and Mapping Agency or NIMA), U.S. Geological Survey, Environmental Protection Agency, U.S. National Park Service, and state, local, and foreign government sources.

MIXED TIDES

Tides characterized by a conspicuous diurnal inequality in the higher high and lower high waters and/or the higher low and lower low waters. Quantitatively, a tide is mixed if the ratio of diurnal tidal constituents K1+O1 to the semidiurnal constituents M2+S2 is between 0.25 and 3.0.

MODIFIED ROUTE CHARTS

NOS charts that are versions of Intracoastal Waterway charts that were originally issued in a conventional chart format. They are identical in construction and format to area charts, and are used for some areas not adaptable to route chart style for long, narrow waterways. See Route Charts.

MOLE

A form of breakwater alongside which vessels may lie on the sheltered side only; in some cases it may lie entirely within an artificial harbor, permitting vessels to lie along both sides.

MONUMENT

In surveying, a structure used or erected to mark the position of a station; permanence is implied.

MOORING

1. A place where a vessel may be secured. 2. The process of securing a vessel, other than anchoring with a single anchor.

MOORING BUOY

A buoy secured to the sea floor by permanent moorings and provided with means for mooring a vessel by use of its anchor chain or mooring lines.

MORAINE

An accumulation of earth, stones, etc., deposited by a glacier, usually in the form of a mount, ridge, or other prominence on the terrain. In charting, these features often exist at the entrance to or within fiord-like waterways and, frequently, contain hazardous shoal depths or rocky obstructions.

MOSAIC

An assembly of side scan sonar records matched in such a way as to show a continuous, two-dimensional representation of an area of seabed.

MOTION REFERENCE UNIT (MRU)

Measures the motion of the vessel or platform, usually Heave, Pitch, and Roll. Yaw is also measured by some MRUs.

MUD FLAT

A muddy, low-lying strip of ground by the shore, or an island, usually submerged more or less completely by the rise of the tide.

MULTIPATH

As related to echo sounding, sonar signals arriving at a target, or returning to a transducer from a single source but along different paths. Multipath returns in imaging sonars typically occur in shallow water or around complex structures, such as petroleum platforms or near piers and pilings. A classic multipath environment for side scan sonar is in shallow water with a flat sea surface. Acoustic echoes will return to the transducer along 3 different paths: 1. transducer - target – transducer; 2. transducer - target - sea surface - transducer; and 3. transducer - sea surface - target - sea surface - transducer. If these 3 return paths take 3 different times, the result will be 3 images of the same target in the data. As related to navigation systems (e.g., GPS) multipath is the corruption of the direct GPS signal by reflection from the local surroundings which adversely affects measurements in a GPS receiver.

7.14 N

NALL

See Navigable Area Limit Line

NARROWS

A navigable narrow part of a bay, strait, river, etc.

NATIONAL GEODETIC VERTICAL DATUM of 1929 [NGVD (1929)]

Previously called the Sea Level Datum of 1929, it was a vertical control datum established for vertical control in the United States by the general adjustment of 1929. The datum was derived for surveys from a general adjustment of the first-order leveling nets of both the U.S. and Canada. In the adjustment, which was made in 1929, mean sea level was held fixed as observed at 21 tide stations in the U.S. and 5 in Canada. The datum (was) not mean sea level, the geoid, or any other equipotential surface. Therefore it was renamed, in 1973, the National Geodetic Vertical Datum on 1929. This vertical datum was in use until the adoption, in 1991, of the North American Vertical Datum of 1988 which held fixed the height of the primary tidal bench mark, referenced to the new International Great Lakes Datum of 1985 local mean sea level height value, at Father Point/Rimouski, Quebec, Canada.

NATIONAL TIDAL DATUM EPOCH (NTDE)

The specific 19-year period adopted by the National Ocean Service as the official time segment over which tide observations are taken and reduced to obtain mean values (e.g. mean lower low ware, etc.) for tidal datums. It is the policy of NOS to consider a revised NTDE every 20-25 years in order to take into account relative sea level changes caused by global sea level change and the effects of long term local land movement due to subsidence or glacial rebound. The present NTDE is 1983-2001. Previous tidal epochs were determined for periods 1924-42, 1941-59, and 1960-78.

NATURAL HARBOR

A harbor possessing natural shelter in a large degree. Natural harbors require only the provision of such facilities as quays or piers and sometimes deepening by artificial means to make them serviceable as shipping ports.

NATURAL SHORELINE

The line of contact between the surface of a body of water and natural land, including islands. It does not include the water line along floating or man-made features, or along rocks smaller than those considered to be islands.

NAUTICAL

Of or pertaining to ships, navigation (chiefly marine), or seamen. In contrast, navigational refers to navigation only; marine refers to the sea; maritime indicates relationship or proximity to the sea; and naval refers to the navy.

NAUTICAL CHART

A representation of a portion of the navigable waters of the earth and adjacent coastal areas on a specified map projection, and designed specifically to meet requirements of marine navigation. Included on most nautical charts are: depths of water, characteristics of the bottom, elevations of selected topographic features, general configuration and characteristics of the coast, the shoreline (usually the mean high water line), dangers, obstruction, aids to navigation, limited tidal data, and information about magnetic variation in the charted area.

NAUTICAL MILE

A unit of distance used in marine navigation, which may be taken as equal to the length of a minute of arc along the equator or a minute of latitude on the map which is being measured. Nearly all maritime nations have adopted the International Nautical Mile of 1,852 m proposed in 1929 by the International Hydrographic Bureau. See Mile.

NAVIGABLE

Affording passage to a craft; capable of being navigated.

NAVIGABLE AREA LIMIT LINE (NALL)

An alongshore survey line that is also known as a shoreline buffer. The shoreline buffer or NALL should be run at or near low water prior to acquiring mainscheme hydrography in the near shore area. The shoreline buffer is a way of providing the hydrographer a “first look” at the near shore detail, which may identify gross discrepancies in the source or charted shoreline, and reveal significant offshore features that may pose a risk to a survey launch at higher water.

NAVIGABLE AREA SURVEYS (NAS)

Basic hydrographic surveys with restricted area coverage. By restricting the area of coverage while retaining the “basic” hydrography concept within surveyed waters, a more rapid progression of field work is realized. The coverage is typically reduced by omitting requirements for: (1) development of the 0-foot depth curve and (2) foul, nearshore areas not considered navigable. Navigable Area Surveys may also be restricted to the main navigable channel or corridor.

NAVIGABLE WATERS

Waters usable, with or without improvements, as routes for commerce in the customary means of travel on water.

NAVIGABLE WATERS OF A STATE

Navigable waterways that lie wholly within the limits of a state and have no navigable connection with any navigable waters outside the boundaries of that state. Such intrastate waters are subject to regulation and control by state laws and do not fall within the jurisdiction of Congress nor of the laws enacted by it for the preservation and protection of the navigable waters of the United States.

NAVIGABLE WATERS OF THE UNITED STATES

Waters which form, in their ordinary condition by themselves, or by uniting with other waters, a continuous highway over which commerce is or may be carried on with other states or foreign countries in the customary modes in which such commerce is conducted by water. This applies also to an artificial canal, even though the canal is wholly within the body of a state and subject to its ownership and control.

NAVIGATION RESPONSE TEAMS

Navigation Response Teams are Office of Coast Survey field units that perform surveys for emergency responses, such as following groundings or hurricanes, and for updating NOS nautical charts. An NRT unit typically consists of a small survey boat capable of being transported by trailer, an office trailer, and a crew of three hydrographers.

NAVIGATIONAL AID

An instrument, device, chart, method, etc., intended to assist in the navigation of a craft. This expression should not be confused with the term “Aids to Navigation”, which refers only to devices external to a craft.

NEAT LINE

A line, usually a grid or a graticule, bounding the detail of a map. Also referred to as inner neat line, to differentiate it from a border drawn outside of a neat line.

NECK

The narrow strip of land with water on each side and connecting two larger bodies of land; an isthmus.

NEW CHART

A chart usually constructed to satisfy the needs of navigation in a particular area, e.g., because the area had no prior adequate chart coverage of the same scale, or because the limits are radically changed. The new chart may cancel an existing chart.

NEW EDITION

A chart issue that cancels a previous issue. If the new information renders that existing chart obsolete, the new printing is designated a new edition. A new edition reflects one or more changes of such importance to navigation that all previous printings are obsolete. Changes may be based on corrections from the Notice to Mariners (NTM) in addition to other sources. The date of a new edition is the date of the latest NGA NTM from which the chart has been corrected. The edition number and date are printed in the lower left corner of the chart.

NIMA (National Imagery and Mapping Agency)

Former name of the National Geospatial-Intelligence Agency (NGA), which was adopted in November 2003.

NOISE

Extraneous signals detected by a sonar that affect the system’s efficiency to display, and the operator’s efficiency to interpret, the signals of interest. Noise can originate from many different sources both internal and external to the sonar system. See Interference.

NOMINAL RANGE

The maximum distance a light may be seen in clear weather (meteorological visibility of 10 Nautical Miles (NM), without regard to the curvature of the earth, the height of the eye, or the height of the light. Listed for all federal lighted aids, except range lights and directional lights.

NON-TIDAL WATERS

Waters not subject to tidal influence. Under Public Law 31, lands beneath such waters of a state which were navigable when the state entered the Union are granted to the state.

NORTH AMERICAN DATUM (NAD)

A horizontal control datum which is the same as United States Standard Datum. The name was changed to North American Datum early in 1913 when Canada and Mexico adopted the United States Standard Datum for their triangulation. This change in name reflected the continental character the datum now assumed.

NORTH AMERICAN DATUM of 1927 (NAD27)

The name to which the North American Datum was changed in 1932 as a result of the unified adjustment of the triangulation in the western half of the country. The North American Datum of 1927 (NAD 27) was the horizontal control datum for the U.S. that was defined by a location and azimuth on the Clarke spheroid of 1866, with its origin at the survey station Meades Ranch, Kansas. The geoidal height at Meades Ranch was assumed to be zero. As of 1963, all of the conterminous United States and the whole of Alaska (including the offshore islands in the Bering Sea) were connected by one continuous triangulation and placed on NAD27.

NORTH AMERICAN DATUM of 1983 (NAD83)

The modern horizontal control datum for the United States, Canada, Mexico, and Central America which is based on a geocentric (earth centered) origin and the Geodetic Reference System 1980. NAD 83 is based on the adjustment of 250,000 points including 600 satellite Doppler stations which constrain the system to a geocentric origin. The computation of the NAD 83 removed significant local distortions from the network which had accumulated over the years, using the original observations, and makes NAD 83 much more compatible with modern survey techniques.

NOTICE TO MARINERS (NTM)

A weekly publication of the NGA, which corrects NGA and National Ocean Service (NOS) charts using information collected from many sources including the U. S. Coast Guard Local Notice to Mariners. The publication contains only those chart corrections of interest to ocean going vessels. NRT See Navigation Response Teams.

NUMERICAL SCALE

The scale of a survey (or chart) expressed in terms of the distance on the earth represented by one unit on the survey, e.g., “1 inch equals 20 miles,” “3 inches to the mile.”

NUN BUOY

An unlighted buoy of which the upper part of the body (above the waterline), or the larger part of the superstructure, has approximately the shape of a cone with vertex upwards.

7.15 O

OBLATE SPHEROID

An ellipsoid of revolution, the minor axis of which is the axis of revolution. The Earth is approximately an oblate spheroid.

OBSCURED

Said of the arc of a light sector designated by its limiting bearings in which the light is not visible from seaward.

OBSOLETE CHART

A chart which is not considered safe to use for navigation because it does not contain the latest important navigational information.

OBSTRUCTION

Anything that hinders or prevents movement, particularly anything that endangers or prevents passage of a vessel or aircraft. The term is usually used to refer to an isolated danger to navigation, such as a submerged rock or pinnacle in the case of marine navigation.

OBSTRUCTION BUOY

A buoy used alone to indicate a dangerous reef or shoal. The buoy may be passed on either hand.

OBSTRUCTION MARK

A navigation mark used alone to indicate a dangerous reef or shoal. The mark may be passed on either hand.

OCCULTING LIGHT

A light in which the total duration of darkness in a period is shorter than the total duration of light and appearances of darkness are usually of equal duration.

OCEANOGRAPHY

The study of the ocean, embracing and integrating all knowledge pertaining to the ocean's physical boundaries, the chemistry and physics of sea water, marine biology and submarine geology.

OCEAN SURVEY SHEETS (OSS)

Antiquated term that refers to survey sheets that cover large areas of the ocean. Limits of the OSS series were designed to conform closely to the U.S. Navy Bathymetric series.

OFFSHORE

In NOAA operational hydrographic terms, the zone extending seaward from depths of 8 m. In general terms, the comparatively flat zone of variable width which extends from the outer margin of the rather steeply sloping shoreface to the edge of the continental shelf.

OFFSHORE WIND

A wind blowing from the land toward the sea.

OFF STATION

Used to describe a floating navigational aid that is not "on station" or in its assigned geographic location.

OLD HAWAIIAN DATUM

The standard horizontal datum for the main Hawaiian islands. Old Hawaiian Datum is an independent datum that was derived from the North American Datum 1927 (NAD27).

ON STATION

Used to describe a floating navigational aid that is in its assigned geographic location. Opposite of Off Station.

ONSHORE WIND

A wind blowing from the sea toward the land.

OOZE

A fine-grained pelagic sediment containing more than 30% organic material combined with amorphous clay-sized material and found only in the greater ocean (abyssal) depths off the Continental Shelf on the abyssal plains. Ooze is a classification by composition, not grain size. Accordingly, considering grain size, ooze is mud but mud is not necessarily ooze. Soft mud is, commonly, improperly referred to as ooze.

OPEN COAST

The coast that fringes the marginal sea, as distinguished from the coast that fringes inland waters. ORIGIN In surveying, the reference position from which angles or distances are reckoned. In cartography, (1) the point of intersection of the coordinate axes, from which the coordinates are reckoned; (2) the origin of coordinates is the point to which the coordinate values (0, 0) are assigned, irrespective of its position with reference to the axes; (3) the origin of coordinates is the point from which the computation of the elements of the coordinate system (projection) proceeds.

ORTHOMETRIC HEIGHT

The distance of a point above the geoid.

ORTHOGONAL

Pertaining to or composed of right angles.

ORTHOPHOTOGRAPH

A photographic copy, prepared from a perspective photograph, in which the displacements of images due to tilt and relief have been removed.

ORTHOPHOTOMAP

A map made by assembling a number of orthophotographs into a single, composite picture. A grid is usually added. It may be further improved, cartographically, by photographically bringing edges out sharply in the picture, or by adding color or symbols.

ORTHOPHOTOQUAD

An orthophotograph, or mosaic of orthophotographs, at the size of a standard U.S.G.S quadrangle (a scale of 1:24,000) with little or no cartographic work added to it.

OUTER CONTINENTAL SHELF

All submerged lands lying seaward and outside of the area of “lands beneath navigable waters,” as defined in section 2(a) of the Submerged Lands Act (43 U.S.C. 1301(a), and of which the subsoil and seabed appertain to the U.S. and are subject to its jurisdiction and control.

OUTER EDGE OF MARSH

The line delineated on topographic surveys as the dividing line between land and water, rather than the high-water line, for use on nautical/navigational charts.

OUTFALL

A structure extending into a body of water for the purpose of discharging sewage, storm runoff or cooling water.

OUT-OF-RANGE

Target echoes displayed by the sonar resulting from hard reflectors that are beyond the system range setting. When an imaging sonar transmits an acoustic pulse, it propagates into the environment. After the pulse travels beyond the set range of the system, another pulse is transmitted. However, the first pulse is still moving away from the transducer and sending back echoes. Even though those echoes are returning from out-of-range, this is not normally a problem because the sonar system gains are reduced in the near field (for the second outgoing pulse). In a quiet environment, where there is little backscatter in the near field and there are hard targets out of range, these targets will be imaged after the second pulse starts its propagation. In radar, this phenomenon is called a "second sweep return."

OUTSIDE SOURCE DATA (OSD)

Previously called Third Party Data. Source data that originates from sources other than the Office of Coast Survey (OCS) hydrographic field units and contractors. Outside sources would include the U.S. Army Corps of Engineers, U.S. Naval Oceanographic Office, USGS, state and local governments, academic institutions and commercial entities not conducting surveys under contract to NOAA/OCS.

OVERFALLS

Short, breaking waves occurring when a strong current passes over a shoal or other submarine obstruction or meets a contrary current or wind.

OVERLAP

The area of seabed between survey lines that is ensonified twice, once by the swath on each side. Planned overlap is useful to assure efficient 100% coverage of the seabed. Since a vessel's track line is not a perfectly straight line, overlap of one swath with a portion of the next will help ensure that there are no data gaps between tracks.

OVERLAY

1. A printing or drawing on a transparent or semitransparent medium at the same scale as a map, chart, etc., to show details not appearing, or requiring special emphasis, on the original. 2. Additional data, or a pattern, printed after the other features so as to “overlay” them. 3. A sheet containing explanatory or modifying data, placed over and keyed to the existing or basic copy. Sometimes used as a means of correcting the underlying copy.

OVERPRINT

Information printed or stamped upon a map or chart, in addition to that originally printed, to show data of importance or special use.

OVER-THE-GROUND

A measurement of the speed or course of a vessel with respect to the seabed, independent of movement in relation to wind or water.

7.16 P

PANTOGRAPH

An instrument which makes use of the properties of a parallelogram, for the mechanical copying of drawings at a predetermined reduced (or enlarged) scale. Once used extensively within NOAA's chart production program to transfer information from a source map to a nautical chart. The tool is no longer used, having been replaced by digital techniques, such as vector digitization.

PARALLEL

A circle (or approximation of a circle) on the surface of the Earth, parallel to the equator and connecting points of equal latitude.

PARITY BIT

A data bit, set at "0" or "1," that provides information on whether the total number of bits in a data field is even or odd. This is used to ensure data integrity and that no data is lost. PASS A single procession by a seabed anomaly during a sonar survey. Multiple passes by a target may be necessary for target classification and interpretation. For example, thermal discontinuities rarely look the same on any two passes. A target that may be a school of fish can be properly identified by multiple passes because fish schools rarely stay in one place over any length of time.

PASSAGE

A narrow navigable channel, especially one through reefs or islands. Sometimes called a pass or, in New England waters, a hole.

PASSING LIGHT

A term applied to a lower candlepower light mounted on a light structure. Used where a mariner passes out of the main light beam (such as a range light) but still needs to keep the structure in sight during transit.

PASSIVE SONAR

A sonar system having only a hydrophone, and capable of receiving signals but not transmitting them.

PATH-TRACKING

The ability of a towed body to accurately follow the path along which it is towed. In the absence of high velocity currents and using short cables, most side scan sonar towfish will track along the ship's path well. However, if the sonar is towed at 90 degrees to a strong current and over long cable, it will tend to be displaced from the vessel's path and heading. See Lateral Offset.

P-CODE

A term related to GPS signals. A bi-phase shift modulated on both the L1 and L2 carrier frequencies. P-code has a 10.23 MHz bit rate and, as implemented in GPS, has a period of 1 week. Each satellite has a unique P-code that is used to distinguish that satellite from all others.

PEBBLES

Beach material, usually well-rounded and between 4 - 64 mm in diameter.

PECKED LINE

A cartographic term describing a symbol consisting of a line broken at regular intervals.

PERCH

A staff placed on top of a buoy, rock, or shoal as a mark for navigators. A ball or cage is sometimes placed at the top of the perch as an identifying mark.

PENINSULA

A body of land jutting into and nearly surrounded by water, frequently (but not necessarily) connected to a larger body of land by a neck or isthmus.

PERIOD

The interval of time necessary for a regularly recurring motion to make a complete cycle. The period of a navigational light is the time taken to exhibit one complete sequence of intervals of light and darkness.

PHASE

Relative measurement describing the temporal relationship between two waves with the same frequency. Phase is measured in degrees, and one full oscillation cycle has 360 degrees. One way to think of phase is this: If two pendulums are swinging at the same frequency and are in the same position at the same instant, then they are in phase with each other.

PHOTOGRAMMETRIC COMPILATION

The production of a map or chart, or portion thereof, from aerial photographs and geodetic control data. When compilation involves stereo instruments, this is called stereocompilation.

PHOTOGRAMMETRIC SURVEY

A survey of a portion of the land surface utilizing aerial photographs and reduced to map form by stereoscopic or other instrumental equipment.

PHOTOGRAMMETRY

1. The science of obtaining reliable measurements from photographic images. 2. The science of preparing charts and maps from aerial photographs using stereoscopic equipment and methods.

PHOTOMOSAIC

1. An assemblage of photographs, each of which shows part of a region, put together in such a way that each point in the region appears once and only once in the assemblage, with scale variation minimized. A photomosaic is assembled by trimming, warping, and fitting together the individual photographs. If the photographs were taken at different heights, the individual photographs must be enlarged or reduced to a common scale. 2. An assemblage of parts of aerial photographs joined together to leave as few variations of scale as possible.

PHOTOTRIANGULATION

The determination of horizontal or vertical coordinates from measurements of angle, distance, or coordinates of points on overlapping photographs. Phototriangulation is classified as terrestrial or aerial, depending on whether the photographs were taken on the ground or from the air. Aerial phototriangulation is commonly called “aerotriangulation.”

PIER

A long, narrow structure extending into the water approximately perpendicular to a shore or a bank to providing berthing for ships, to serve as a promenade or place for other use, as a fishing pier.

PIERHEAD

That part of a pier or jetty projecting farthest into the water.

PIERHEAD LINE

The line fixing the boundaries of the fairway to which wharf or pier structures (of open construction) may be built.

PILE

A long substantial timber or section of wood, concrete, or metal, forced into the earth or seabed to serve as a support, as a pier, or to resist lateral pressure.

PILING

Plural form of Pile. Sometimes used to describe a row of piles.

PILLAR BUOY

A buoy composed of a tall central structure mounted on a broad flat base. Also called a beacon buoy.

PILOT

One who provides guidance to a vessel’s captain regarding the movements of a vessel through pilotage waters; usually, one who has demonstrated extensive knowledge of channels, aids to navigation, dangers to navigation, etc., in a particular area and is licensed for that area.

PILOT AREA

A pilot area represents a meeting or boarding place where vessels pick up or disembark licensed pilots. A pilot vessel may either cruise in the area continuously or come out upon request.

PING

A single transmitted output pulse of a sonar system; also, the reflected return signal from a single output.

PINNACLE

On the sea floor, a high tower or spire-shaped pillar of rock or coral, alone or cresting a summit. It may extend above the surface of the water. It may or may not be a hazard to surface navigation.

PIPE

A hollow metal tube imbedded in the bottom in a manner similar to a pile. Pipes will vary in diameter and length, and are often used as privately maintained aids to navigation.

PITCH

An instability in vessel or towfish attitude expressed by the alternate rise and fall of the bow/nose and stern/tail about a horizontal axis.

PLANE RECTANGULAR COORDINATES

A system of coordinates in a horizontal plane, used to describe the positions of points with respect to an arbitrary origin. The origin is established by a pair of axes which intersect at right angles. The position of a point is determined by the perpendicular distances to these axes. Also call plane coordinates.

PLANETABLE

A surveying instrument used in topographic mapping by which the surveyor plots his survey in the field directly from the observations, without the necessity of keeping notes for later office plotting. It consists essentially of a drawing board on a tripod to which the survey sheet is clamped and adjusted in the horizontal plane, an alidade (a telescope mounted on a metal, straight-edge ruler) for measuring directions and distances to salient features of the terrain, and a telemeter rod graduated for the optical measurement of distances from the observer.

PLANIMETER

A mechanical integrator for measuring the area of a plane surface.

PLANIMETRIC SURVEY

A survey which presents the horizontal position only for the features represented; distinguished from a topographic map by the omission of relief.

PLAT

A diagram drawn to scale showing land boundaries and subdivisions, together with all data essential to the description and identification of the several units shown thereon, and including one or more certificates indicating due approval. A plat differs from a map in that it does not necessarily show additional cultural, drainage, and relief features.

PLATFORM

1. In oceanographic terminology, any man-made structure (aircraft, ship, buoy, or tower) from which or on which oceanographic instruments are suspended, installed, or operated. 2. Any offshore fixed or floating structure providing a flat or specially designed working surface above the water which serves a specific and/or specialized purpose, e.g., drilling, survey, research, potable water intake, swimming-diving, or storage functions.

PLOT

1. A map, chart, or graph representing data of any sort. 2. To represent on a diagram or chart the position or course of a target in terms of angles and distances from known position; to locate a position on a map or a chart. 3. A portion of a map or overlay on which are drawn the outlines of the areas covered by one or more photographs. 4. To generate graphic images according to a given system of coordinate values, such as scale factor. 5. To use a plotter.

PLOTTING SHEET

(Used prior to digital plotters) A blank chart, usually on the Mercator projection, showing only the graticule and a compass rose, so that the plotting sheet can be used for any longitude. In hydrographic surveying, a working sheet on which the main stations of the survey are plotted. It formed the framework of the survey and provided the basis for accurately locating and plotting all the detail of the survey.

POINT

1. The extreme end of a cape, or the outer end of any land area protruding into the water (less prominent than a cape). 2. A place having position, but no extent. 3. One thirty-second of a circle, or 11 ¼ °. A cardinal point is any of the 4 principal directions, north, east, south, or west; an intercardinal point is any of the 4 directions midway between the cardinal points, northeast, southeast, southwest, or northwest. Also called compass points when used in reference to compass directions.

POINT FEATURE

A point feature is a single point item such as a pile, wreck, rock, obstruction, etc. located at one specific geographic location. This may include detached positions for data types such as bottom samples, sound velocity cast locations, navigational aids, feature disprovals, existing navigationally significant features, and AWOIS items.

POINT SYMBOL

A symbol employed to indicate that a particular phenomenon occurs at, or a particular value may be attributed to, a specific point on a map.

POLAR COORDINATES

1. A coordinate system based on a sphere. 2. An alternative system of marking a point on a plane by its radial distance (r) from an "origin" and a polar angle (f). When 3-dimensional polar coordinates overlap a Cartesian (x, y, z) system, q is the angle between the line to the origin and the z-axis, while f is the (counter-clockwise) angle between the projection of that line onto the (x,y) plane and the x-axis. Concerning(q, f), see also latitude and longitude, declination, azimuth and elevations. 3. An alternative to the usual Cartesian method of addressing image pixels. Polar coordinates use the coordinate pair, angle and radius from an origin instead of column and row. 4. A 2-D coordinate system used to locate a point in a plane by specifying a distance and an angle from the coordinate origin. If another distance normal to the coordinate origin is added, cylindrical coordinates can be specified.

POLE

An elongated rod of wood or metal driven into the bottom to serve a particular purpose. Of smaller diameter than a pile, but larger diameter than a stake.

POLYCONIC PROJECTION

A map projection having the central geographic meridian represented by a straight line, along which the spacing for lines representing the geographic parallels is proportional to the distances between the parallels; the parallels are represented by arches of circles that are not concentric, but whose centers lie on the line representing the central meridian, and whose radii are determined by the lengths of the elements of cones which are tangent along the parallels. All meridians except the central ones are curved. The projection is neither conformal nor equal area, but it has been widely used for maps of small areas because of the ease with which it can be constructed. The origin of the projection, at least in concept, is credited to Ferdinand R. Hassler, the first Superintendent of the Coast Survey, and was used for all the hydrographic surveys of the agency until the 1990s.

PONTOON BRIDGE

A bridge supported on pontoons.

PORT

A place for the loading and unloading of vessels recognized and supervised for maritime purposes by the public authorities. The term includes a city or borough for the reception of mariners and merchants, and therefore denotes something more than a harbor. A port may possess a harbor but a harbor is not necessarily a port. Any natural creek or inlet on the sea shore with adequate depth of water and sufficient shelter for ships fulfills the essential conditions of a harbor. To make it a port, in the accepted sense of the word, there must be additional accommodations and facilities for landing passengers and goods.

PORT SERIES

A series of reports, published jointly by the U.S. Army Corps of Engineers (USACE), the Maritime Administration (MARAD), and the U.S. Department of Transportation (DOT). The reports describe in detail pilotage information for the principal ports of the United States, as well as the facilities and services available to shipping at selected U.S. seaports.

POSITION

Data which define the location of a point with respect to a reference system. The coordinates that define a location. The place occupied by a point on the surface of the Earth, or in space.

POSITION APPROXIMATE

Of inexact position. The expression is used principally on charts to indicate that the position of a wreck, shoal, etc., has not been accurately determined or does not remain fixed. Usually shown by the abbreviation “PA.”

POSITION DOUBTFUL

Of uncertain position. The expression is used principally on charts to indicate that a wreck, shoal, etc., has been reported in various positions and not definitely determined in any. Usually shown by the abbreviation “PD.”

POSITION NUMBERS

Numbers historically assigned to a “fix” of the survey boat’s position at one particular time, starting with number 1 at the beginning of the survey and continuing consecutively to the end of the survey.

POSITION REPORTED

The reported location of a feature. Usually, this refers to the geographic location of a feature that has been reported to proper authorities, such as the U.S. Coast Guard or local marine agencies. Usually shown on charts by the text “reported.”

POST

A small beacon used for marking channels. This beacon is usually more substantial than a perch, and has a diameter larger than that of a stake but smaller than that of a pile.

POST-PROCESSING

Data processing performed after real-time data acquisition.

POTABLE WATER INTAKE (PWI)

A structure designed for the intake of drinking water. The intake is usually elevated above the bottom, and supported and protected by a debris-screening structure (crib), usually a separately charted feature.

POUND NET

A set net composed of vertical netting supported and held in place by stakes. It consists of three essential parts, the pot (pound, pocket, bowl), the wings or hearts, and the leader or lead. The pound consists of a bag of stout netting with 1-in meshes the margin of which is supported by upright stakes. The bottom of the pound is spread and secured by ropes which pass through loops near the lower end of the stakes. The wings or heart are vertical fences of netting diverging from the entrance of the net. The mesh is ½ -in and is supported by stakes.

The leader, which may vary in length from about 150 - 1,000 ft or more, extends from shore or shallow water into deeper water, and deflects the fish towards the heart or wings.

PRECAUTIONARY AREA

A routing measure comprising an area within defined limits where ships must navigate with particular caution and within which the direction of traffic flow may be recommended.

PRECISION

The degree of refinement of a value; not to be confused with its accuracy, which is the degree of conformance with the correct value.

PREDICTED TIDES

Tide levels that are predicted by combining the harmonic constituents over time at a particular tidal location.

PRELIMINARY CHART

A chart for which there is a requirement, but for an area in which some or all of the survey data does not meet modern standards. The deficiencies in such surveys may be due to small scale, out-moded, or non-standard survey techniques, outdated, unprocessed, or unapproved data, or other factors causing the survey data to fall below customary standards for the scale of the chart. A preliminary chart may or may not be published in full color. Included on the chart shall be a source diagram and a warning note stating that (all or much of) the hydrography shown on the chart is not of customary quality. The chart will retain the "Preliminary" label until it has been recompiled using contemporary, processed, and approved source material, and all standard chart colors shown.

PRELIMINARY SURVEY

As used in historical NOAA terminology, this was a survey that was of higher order than a reconnaissance, but did not have the detail of a complete survey.

PRIMARY GAUGE (Primary Control Water Level station)

A water level station at which continuous observations have been made over a minimum of 19 years. Its purpose is to provide data for computing accepted values of the harmonic and nonharmonic constants essential to tide predictions and to the determination of tidal datums for charting an for coastal and marine boundaries. The data series from these stations serves as a primary control for the reduction of relatively short series from subordinate tide stations through the method of comparison of simultaneous observations and for monitoring long-period sea level trends and variations.

PRIME MERIDIAN

The meridian of longitude 0°, used as the origin for measurement of longitude. The meridian of Greenwich, England, is almost universally used for this purpose.

PRINCIPAL MERIDIAN

A true north-south line (a meridian), extending both north and south of the initial point in the rectangular system of surveys. Together with the base line, principal meridians constitute the axes of a system and the initial point of origin of that system.

PRIVATE AIDS TO NAVIGATION

In U.S. waters, those aids to navigation not established and maintained by the U.S. Coast Guard. Private aids include those established by other federal agencies with prior U.S. Coast Guard approval, those aids to navigation on marine structures or other works which the owners are legally obligated to establish, maintain, and operate as prescribed by the U.S. Coast Guard, and those aids which are merely desired, for one reason or another, by the individual corporation, state or local government, or other body that has established the aid with U.S.

Coast Guard approval. Although private aids to navigation are inspected periodically by the U.S. Coast Guard, the mariner should exercise special caution when using them for general navigation.

PROBABLE ERROR

An error (or deviation from the mean) of such magnitude that the likelihood of its being exceeded in a set of observations is equal to the likelihood of its not being exceeded (50% probability); its value is that of the standard error multiplied by 0.6745. The use of standard error is sometimes preferred {to probable error} in statistical studies.

PROJECT INSTRUCTIONS

A document issued by NOAA's Office of Coast Survey containing the unique requirements for a hydrographic survey project. It pertains only to those projects to be conducted by NOAA survey platforms and hydrographers and is not intended to be used by others working under contract. This term supersedes the term Letter Instructions.

PROJECT/VESSEL/DAY/LINE (PVDL)

Hierarchical format used to store CARIS hydrographic data.

PROJECTION

The representation of a figure on a surface, either plane or curved, according to a definite plan. In a perspective projection this is done by means of projecting lines emanating from a single point, which may be infinity. In cartography, any systematic arrangement of meridians and parallels portraying the curved surface of the sphere or spheroid upon a plane. Also called map projection or chart projection.

PROJECTOR

A sonar transducer that translates electrical signals into pressure waves (sound signals), and transmits them through the water.

PROLATE SPHEROID

An ellipsoid of revolution, the major axis of which is the axis of revolution.

PROOF

In cartography, an advanced copy of a map produced to check the design, register and/or to enable errors to be detected and corrected before final printing.

PROOF CHECKING

The examination of the proof and comparison with its sources to point out any errors, omissions, and necessary improvements.

PROPORTIONAL DIVIDERS

An instrument consisting in its simple form of two legs pointed at both ends and provided with an adjustable pivot, so that for any given pivot setting, the distance between one set of pointed ends always bears the same ratio to the distance between the other set. A change in the pivot changes the ratio. The dividers are used in transferring measurements between different charts or drawings that are not at the same scale.

PROVISIONAL CHARTS

A special chart for which there is an urgent need. The chart is compiled from processed and approved source material and may be smooth drafted for direct reproduction. All charted information is combined on the black plate and no colors are shown. The chart will retain the "provisional" label until all smooth drafted detail is engraved and standard chart colors are added.

PUBLICATION NO. 9

American Practical Navigator; a publication of the NGA, originally by Nathaniel Bowditch, comprising an epitome of navigation and navigational astronomy and providing tables for solution of navigational problems. Popularly called Bowditch.

PUBLIC LAW 31 (SUBMERGED LANDS ACT)

An act passed during the 1st session of the 83rd Congress and signed into law on May 22, 1953. Confirms and establishes the titles of the states to lands beneath navigable water within their boundaries and to the natural resources within such lands and water. The act also established jurisdiction and control of the United States over the natural resources of the seabed of the continental shelf seaward of state boundaries.

PUBLIC LAW 212 (OUTER CONTINENTAL SHELF LANDS ACT)

An act passed during the 1st session of the 83rd Congress and signed into law on August 7, 1953. Provides for the jurisdiction, control, and administration by the United States over the submerged lands seaward of the states' boundaries as defined in Public Law 31, that is, over the outer continental shelf.

PUBLISHER'S NOTE

A marginal note which indicates the publisher and usually the place of publication.

PULSE

A short burst of sonar, typically measured as a function of time, distance, or power. Each pulse of sonar is also known as a ping.

PULSE LENGTH

The length of time that an active sonar is transmitting one pulse, typically expressed in milliseconds. Longer pulse lengths allow more power to be put into the water at the expense of across track resolution. This has the effect of gaining range for large area surveying.

PULSE WIDTH

The distance of the ensonified water, in the range dimension, at a given point in time, expressed in meters and determined by multiplying the pulse length by the speed of sound through the water. Pulse widths are measured to determine the maximum theoretical resolution of an imaging sonar.

PUMPING PLATFORM COMPLEX (PPC)

A single platform or a series of inter-connected platforms that have one or more of the following capabilities: (1) Pumping oil between a vessel and the shore; (2) berthing and messing facilities for assigned personnel; (3) a landing area for helicopters; (4) mooring and loading for small vessels.

7.17 Q

QUAD

A commonly used slang expression for "quadrangle." The term used to refer to a topographic map published by the U. S. Geological Survey.

QUALITY ASSURANCE

A continuing evaluation of the quality control process. It is not a double check on each product, but rather a "check on the checkers." Quality assurance techniques often employ a statistical sampling method to examine just enough of the products to determine that the quality control system is effective. Quality assurance is not intended to catch all the deficiencies, but only to determine if the rates of deficiencies that pass through the quality control system are within the acceptable limits established by management. Any problem identified by the quality assurance process should result in corrective action in the quality control process. Since quality assurance evaluates part of the production system, i.e., quality control, it must be organizationally separately from the production manager in order to ensure objectivity.

QUALITY CONTROL

A routine inspection to insure that the product conforms with certain minimum standards and specifications that have been established by management. Quality control is usually performed at the work site by supervisors or by designated inspectors. Products that fail to meet the minimum standards are reprocessed or destroyed.

QUALITY CONTROL REPORT

Historically, a report comprising a critique of the quality and adequacy of the field data acquisition and processing of a given survey. Significant errors, conflicts, or discrepancies which cannot be expeditiously corrected in the records or on the smooth sheet were discussed, and appropriate recommendations regarding corrective action were included in the report. During the period from October 1975 through September 1982, all hydrographic surveys were subjected to a quality control inspection.

QUAY

A structure approximately parallel to the shoreline and accommodating ships on one side only, the other side being attached to the shore. It is usually of solid construction, as contrasted with the open pile construction usually used for piers. A similar facility of more open construction is called a wharf.

QUENCH

The loss of a sonar signal, most often due to water-borne discontinuities and resulting in blank sonar display areas. Quenching will affect both the outgoing sonar pulse and the returning echoes.

QUENCHING

The great reduction in underwater sound transmission or reception resulting from absorption and scattering of sound energy by air bubbles entrapped around the sonar dome.

7.18 R

RACE

Swiftly flowing water in a narrow channel or river; also the channel itself, which may be artificial, as in a mill-race. Also, a swift rush of water through a narrow channel in tidal waters, caused by the tidal movement of the waters.

RADIO ACOUSTIC RANGING (RAR)

A method of position determination in offshore hydrographic surveying which utilized underwater sound transmission and radio to determine the distance of the survey vessel from two or more known stations. This method was discontinued during World War II and has since been superseded by electronic methods.

RADIO BEACON

Electronic apparatus which transmits a radio signal to provide a line of position for marine navigation.

RAMP

A sloping structure that can be used, either as a landing or launching place, at variable water levels, for small vessels, landing ships, or amphibious airplanes, or for hauling a cradle carrying a vessel.

RANDOM ERROR

An error whose occurrence depends on the laws of chance only. Random errors are typically very small with a mean value of zero.

RANGE

1. In hydrographic positioning, the distance between the vessel or observer and a remote control station or range measuring instrument. 2. In navigation, two or more objects in a line. Such objects are said to be in a range. An observer having them in range is said to be on the range. Two beacons are frequently located for the specific purpose of forming a range to indicate a safe route or the centerline of a channel. 3. When referring to side scan sonar, a sonar setting which represents a distance, usually measured in meters, that is the maximum distance from the towfish that the sonar will display (the range setting on the sonar also determines the time between outgoing sonar pulses); also synonymous with the across-track dimension. Once the range setting on the system is set, when returning echoes arrive from that distance away from the transducer, the ping cycle starts again and a new acoustic pulse is transmitted in to the water.

RANGE-AZIMUTH

A method of determining a geographic position using both (a) the range or distance from a control point to a survey vessel, and (b) the azimuth or direction as observed from the same control point to that vessel.

RANGE OF TIDE

The difference in height between consecutive high and low waters. The mean range is the difference in height between mean high water and mean low water.

RANGE RESOLUTION

The ability of the sonar to image, separately and distinctly, objects perpendicular to the towfish heading. The range resolution is determined, in part, by the pulse length of the sonar. A short pulse length will display two targets close together as separate and distinct anomalies. The same two targets, when ensonified by a longer pulse length can be simultaneously enveloped by the pulse. This results in the two objects appearing as one in the sonar display.

RASTER

A matrix of row and column data points whose values represent energy being reflected or emitted from the object being viewed. These values, or pixels, can be viewed on a display monitor as a black and white or a color image. Raster images are made up of individual dots, each of which has a defined value that precisely identifies its specific color, size, and place within the image. Unlike a vectorized raster, which contains attributed information, a raster image does not contain any feature information. Also known as a bitmapped image.

RAY BENDING

See Refraction

REACH

The comparatively straight segment of a river or channel between two bends. That part of a winding river between the last bend and the sea is called a sea reach; that part between the harbor and the first bend is called the harbor reach.

REAL TIME KINEMATIC (RTK)

A DGPS process where GPS carrier-phase (which delivers the most accurate GPS information) corrections are transmitted in real-time from a reference receiver at a known location to one or more remote rover receivers.

RECIPROCAL BEARING

A bearing differing by 180°, or one measured in the opposite direction, from a given bearing.

RECOGNITION

The acknowledgment by the sonar operator of the existence of a target or anomaly as displayed in the sonar data. Lack of anomaly recognition can be problematic particularly during side scan sonar operations. Catastrophic towfish altitude loss, severe fish instability, and search targets all should be recognized by the operator any time they occur. Recognition is distinguished from detection as being operator-dependent. See Detectability.

RECONNAISSANCE SURVEY

A hasty preliminary survey of a region made to provide some advance information regarding the area which may be useful to the mariner, pending the execution of more complete surveys.

RECONSTRUCTED CHART

This term is used when the accumulation of new charting information is sufficiently extensive enough to affect most of an existing chart. This may also occur if there are changes to the chart limits or if the chart is to be recompiled on a new projection using computer-supported compilation and scribing techniques.

RECOVERY OF STATION

In surveying, the identifying and checking of an original station. This is considered as recovered when its mark (monument) is identified as authentic and proved to be occupying its original site.

RECREATIONAL CHARTS

These agency charts are a series of large-scale charts providing sequential page coverage for selected Great Lakes areas. These charts are published in book format with each page being a large-scale, small-sized chart.

RECTANGULAR COORDINATES

Magnitudes defining a point relative to two perpendicular lines called axes. The magnitudes indicate the perpendicular distance from each axis. The vertical distance is called the ordinate and the horizontal distance the abscissa. This is a form of Cartesian coordinates.

REDUCTION OF SOUNDINGS

The correction of observed depths for instrument errors, systematic bias, sound velocity variation, draft and water level above datum.

REEF

A rocky or coral elevation which may be dangerous to surface navigation, sometimes uncovering at the sounding datum. A rocky reef is always detached from shore; a coral reef may or may not be connected with the shore.

REFERENCE LINE

Any line which can serve as a reference or base for the measurement of other quantities. Also called a datum line.

REFERENCE MARK

In surveying, a supplementary mark of permanent character close to a station or to a base terminal, to which it is related by an accurately measured distance and direction, and/or a difference in elevation.

REFERENCE POINT

Any point which can serve as a reference or base for the measurement of other quantities. Also called a datum point.

REFERENCE SPHEROID (OR ELLIPSOID)

A theoretical figure whose dimensions closely approach the dimensions of the geoid. The exact dimensions are determined by various considerations of the section of the Earth's surface considered. The Spheroids of Bessel, Clarke, Delambre, Everest, Hayford, Helmett, and others have been adopted as reference spheroids in geodetic work by different countries.

REFLECTING PROJECTOR

An instrument by means of which the image of a photograph can be projected onto a map. By varying the position of the projector lens, the scale of the projected image can be varied.

REFRACTION

The change of direction of a sound beam when passing obliquely from one medium into another, where its wave velocity is different. Refraction is a type of ray bending that will affect acoustic returns for proper sonar imaging. This occurs when sonar pulses encounter thermal and haline discontinuities. In a normal summer thermocline environment, a side scan beam can be refracted sharply to the seafloor, severely limiting range.

REGISTER MARKS

Designated marks, such as small crosses, circles, or other patterns applied to original copy prior to reproduction to facilitate registration of plates and to indicate the relative positions of successive impressions. Also called corner marks, corner ticks, register ticks, registration ticks, or ticks.

REGISTRATION

Correct positioning of one component of a composite map image in relation to the other components. Map registration (also called geo-referencing) is the process of converting file or page coordinates to map coordinates. For example, a scanned map can have an origin point and a raster association where each point on the map is identifiable by its file coordinates, whether by numerals or by pixels. The task is to then convert these numeral coordinates to map coordinates (e.g., latitude, longitude: x, y).

REGISTRY NUMBER

A number assigned to topographic and hydrographic surveys within NOAA for identification and filing purposes. Topographic surveys are identified by a variety of designations, depending on vintage, e.g., "T," "TP," "DM," and "GC." Hydrographic surveys are similarly identified with designations such as "H," "FE," "S," and "D." Registry numbers beginning with the letter "W" are used to identify surveys originating with sources other than those under the direct administrative control of NOAA.

REMOTE HEAVE

The apparent vertical motion of a sensor due to vessel roll and/or pitch acting on a lever arm between the sensor and the vessel's center of motion.

REPEATABILITY

A measure of the variability of a series of measurements of the same quantity/position/depth. High repeatability is indicative of high precision.

REPRESENTATIVE FRACTION (RF)

The scale of a map or chart expressed as a fraction or ratio that relates unit distance on the map to distance measured in the same unit on the ground. Also called natural scale, fractional scale.

REPRINT

A reprinting of a chart without revision, necessitated by the depletion of stock. The issue is an exact duplicate of the current issue with no changes in printing or publication dates.

RESIDUAL ERROR

The difference between any value of a quantity in a series of observations, corrected for known systematic errors, and the value of the quantity obtained from the adjustment of that series. Sometimes called residual.

RESTRICTED AREA

A specified area designated by appropriate authority and shown on charts within which navigation is restricted in accordance with certain specified conditions.

RESTRICTED WATERS

Areas which for navigational reasons, such as the presence of shoals or other dangers, confine the movements of shipping within narrow limits.

RETRACTABALE BRIDGE

A bridge with a movable span that can be withdrawn horizontally or within the remaining structure of the bridge.

REVERBERATION

The echoing of a sonar signal from a target or targets. Echo and reverberation are often used interchangeably, although targets are more often described as returning an echo whereas large ensonified areas such as the seafloor are described as reverberating under the influence of sonar.

REVETMENT

A retaining wall or facing constructed of riprap or concrete, etc., built to protect an embankment or shore structure against erosion by wave action or currents.

REVIEW

The final step in the processing of the field data or a hydrographic survey. Its purpose was to consider the survey in its broader aspects, to correlate it with all prior surveys of the agency covering the same area, with historical data that may have been received from other sources, and to lay the foundation for future surveys in the area because of indicated changes, inadequate development, or conflicting information. In 1982, this step was effectively merged into a process called Evaluation, the results of which are documented in an Evaluation Report. See also Review Report, Verifier's Report.

REVIEW REPORT

A report, formerly prepared in agency headquarters, which summarizes pertinent facts relating to a given hydrographic survey. Included in the report are sections which address the quality of the hydrographic survey and detailed comparisons made with prior hydrographic surveys and the appropriate nautical charts. Included in the report are specific evaluations and recommendations regarding the adequacy of the survey to supersede prior survey data and charted information. The formal review function was transferred to the Office of Marine Operations in October, 1975, and the former "Review Report" was renamed the "Verifier's Report." See Review, Evaluation Report, and Verifier's Report.

REVISED PRINT

A chart issue that does not cancel a current edition; the revisions are minor and the edition number remains the same, but the print date is changed, and the chart is designated a revised print of that chart. The date of a revised print is shown to the right of the edition date.

RHUMB DISTANCE

The length of the tack a ship makes when sailing from one place to another without changing course.

RHUMB LINE

A line on the surface of the earth making the same oblique angle with all meridians; a loxodrome or loxodromic curve spiraling toward the poles in a constant true direction. Parallels and meridian, which also maintain constant true directions, may be considered special cases of the rhumb line. A rhumb line is a straight line on a mercator projection.

RIFFLE

A shoal, reef, or shallow in a stream, producing a stretch of ruffled or choppy water.

RIGHT BANK

The river bank on the right-hand side as one proceeds downstream.

RINGING

In a transducer, this is the reception of the transducer output pulse at the time of transmission. In active sonar systems, the projector and the hydrophone are one and the same, so the hydrophone receives its own outgoing pulse. In a target, this is a well-documented phenomenon resulting from multiple echoes from certain types of targets due to the acoustical physics of sound pulse wrap-around and reflections internal to the target.

RIPARIAN BOUNDARIES

Water boundaries, or boundaries formed by the sea or a river. The general rule is that riparian boundaries shift with changes due to accretion or erosion but retain their original location. Such changes may be due to rapid erosion of the shoreland by waves during a storm, sudden cutting off of land by flood, currents, or change in course of a body of water, or by artificial causes.

RIP-RAP

A layer, facing, or protective mound of stones or similar durable material, emplaced as in a revetment to prevent erosion, scouring, or sloughing of a structure or embankment.

RISE

A long, broad elevation that rises gently and generally smoothly from the sea floor.

RIVER

A natural stream of water, of greater volume than a creek or rivulet, flowing in a more or less permanent bed or channel, between defined banks or walls, with a current which may either be continuous in one direction or affected by the ebb and flow of the tide.

ROAD

An open anchorage affording less protection than a harbor. Some protection may be afforded by reefs, shoals, etc. Often used in the plural. Also called roadstead.

ROADSTEAD

An area of the sea used for the anchorage of vessels and transshipment of cargo, usually without the protection from weather associated with ports and harbors. Roadsteads are part of the territorial sea but are not inland waters.

ROCK

An isolated rocky formation or a single large stone, usually one constituting a danger to navigation. It may be always submerged, always uncovered, or alternately covered and uncovered by the tide.

ROCK AWASH

In tidal areas, a rock that uncovers, or nearly uncovers, near the vertical datum of reference prescribed for that area. See Sunken Rock.

ROCKY AREA

An area with a rocky bottom.

ROLL

The rhythmic movement of a ship or towbody about its longitudinal axis.

ROOT MEAN SQUARE ERROR

See Standard Error.

ROTATION

Turning of a body about an axis within the body, as the daily rotation of the Earth.

ROV

Acronym for Remotely Operated Vehicle (submersible), an unmanned underwater vehicle that is connected to an operator via a power and/or communication tether. See AUV.

ROUTE CHARTS

Nautical charts produced by the agency and designed for river and narrow waterway coverage, and for much of the Intracoastal Waterway. They are published in the small-craft pocket fold format.

RUINS

A ruin is a structure in a decayed or deteriorated condition resulting from neglect or disuse, or a damaged structure in need of repair. A ruin is considered hazardous if it extends over or into navigable waters and thus represents a danger to surface navigation.

RUB-TEST

The process of manually creating friction on a transducer face in order to test system electrical continuity. Before a sonar towbody is put in the water, it is a common practice to test the system on deck. Because air is a high impedance medium for sonar, the best method of testing system function is to rub the transducer face. In a dual channel side scan sonar, one transducer is rubbed, then the opposite is rubbed to clarify that the transducers are not wired to the wrong display channels.

7.19 S

SAILING CHARTS

Charts of scales 1:600,000 and smaller for planning and for fixing the mariner's position as she approaches the coast from the open ocean, or for sailing between distant coastwise ports. The shoreline and topography are generalized and only offshore soundings, principal navigational lights and buoys, and landmarks visible at considerable distances are shown.

SAILING DIRECTIONS

Publications similar in scope to the Coast Pilots of the agency, published by other hydrographic offices.

SALINITY

A measure of the quantity of dissolved salts in sea water. It is normally defined as the total amount of dissolved solids in sea water in parts per thousand (0/00) by weight when all the carbonate has been converted to oxide, the bromide and iodide converted to chloride, and all organic matter is completely oxidized. In practice, salinity is not determined directly but is computed from chlorinity, electrical conductivity, refractive index, or some other property whose relationship to salinity is well established.

SAND

An unconsolidated mixture of inorganic soil (which may include disintegrated shells and coral), consisting of small but easily distinguishable grains ranging in size from about 0.062 mm to 2.0 mm.

SANDING

An irregular dot pattern used on some of the early hydrographic surveys to accentuate the area between the high- and low-water lines.

SAND SPIT

A narrow embankment, created by an excess of deposition at its seaward terminus, with its distal end (the end away from the point of origin) terminating in open water.

SAND WAVES

1. Longshore sand waves are large-scale features that maintain form while migrating along the shore with speeds on the order of kilometers per year. 2. Large-scale asymmetrical bedforms in sandy river beds having high length to height ratios and continuous crestlines.

SATELLITE POSITIONING SYSTEM

A positioning system consisting of a radio-receiver, or a receiver and transmitter, at the point whose location is to be determined, one or more beacons or transponders in orbit about the Earth, and a computing system for determining and predicting the orbits. The satellites can be considered points of known location. The radio receiver may measure times of travel of radio pulses, directions to the satellites, or the Doppler shift in the frequency of the radio waves emitted by the satellites. The most common system used today is the Global Positioning System (GPS).

SCALE

The relation that a measured distance on a survey, map, or chart bears to the corresponding actual distance on the earth; for example, if 1 inch on the survey or chart corresponds to 1,000 ft (12,000 inches) on the ground, the scale would be expressed as 1 inch = 1,000 ft. Expressed as a ratio, this would be a scale of 1:12,000.

SCALE BAR

A graduated line on a map, plan, photograph, or mosaic, by means of which actual ground distances may be determined.

SCALE FACTOR

A multiplier for reducing a distance obtained from a map by computation or scaling to the actual distance on the datum of the map.

SCALE MARKS

Equidistant, regular marks on a sonar display used to assist in the mensuration of targets above the seafloor, or to provide information on the range displacement of targets from a side scan sonar towfish path.

SCATTERING

The diffusion of a sonar signal in many directions through refraction, diffraction and reflection, primarily due to the material properties of the ensonified areas. Scattering is one of the causes of attenuation in sonar, resulting in signal weakening. See Backscatter.

SEA

1. A large body of salt water, second in rank to an ocean, more or less landlocked, and generally part of, or connected with, an ocean or a larger sea. 2. State of the surface of the ocean or lake with regard to wave or swell, as a calm sea.

SEABOARD

The region of land bordering the sea. The terms seaboard, coast, and littoral have nearly the same meanings. Seaboard is a general term used somewhat loosely to indicate a rather extensive region bordering the sea. Coast is the region of indefinite width that extends from the sea inland to the first major change in terrain features. Littoral applies more specifically to the various parts of a region bordering the sea, including the coast, foreshore, backshore, beach, etc.

SEA BUOY

The outermost buoy marking the entrance to a channel or harbor.

SEA CLUTTER

The images created in a sonar display by acoustic returns from a rough sea surface. When using side scan sonar, some energy is projected above the horizontal from the wide vertical beam. If the sea surface is rough and within the range setting of the system, formless patches may overlay the normal seabed returns.

SEAFLOOR

The bottom of the ocean when there is a generally smooth gentle gradient. Also referred to as the sea bed or sea bottom.

SEA GRASS

Members of marine seed plants that grow chiefly on sand or sand-mud bottom. They are most abundant in water less than 9 m deep. The most common varieties are: eel grass, turtle grass, manatee grass.

SEA MILE

An approximate mean value of the nautical mile equal to 6080 feet, or the length of a minute of arc along the meridian at latitude 48°.

SEAMOUNT

An isolated or comparatively isolated elevation rising 1000 meters or more from the seafloor and of limited extent across the summit.

SEA STATE

The numerical or written description of ocean surface roughness. For more precise usage, sea state may be defined as the average height of the highest one-third of the waves observed in the wave train.

SEAWALL

A structure built along a portion of a coast primarily to prevent erosion and other damage by wave action. It retains earth against its shoreward face.

SEA WATER

The water of the seas, distinguished from fresh water by its appreciable salinity. The degree of salinity greatly affects the water's physical characteristics.

SECCHI DISK

Circular disk used to measure the transparency of the water column.

SECONDARY GAUGE (Secondary Control Water Level Station)

A water level station at which continuous observations have been made over a minimum period of 1 year but less than 19 years. The series is reduced by comparison with simultaneous observations from a primary gauge. This station provides for a 365-day harmonic analysis including the seasonal fluctuation of sea level.

SECONDARY PHASE FACTOR CORRECTION

A correction for additional time (or phase delay) for transmission of a low-frequency signal over an all-seawater path when the signal transit time is based on the free-space velocity. The LORAN-C lattices as tabulated in tables or overprinted on the nautical chart normally include compensation for secondary phase factor.

SEDIMENT

Loose fragments of rocks, minerals, or organic material that are transported from their source for varying distances and deposited by air, wind, ice, and water. Other sediments are precipitated from the overlying water or form chemically in place. Sediment includes all the unconsolidated materials on the sea floor.

SELECTIVE AVAILABILITY (SA)

Selective Availability is a process once used by the U.S. Department of Defense to dither the satellite clock and/or broadcasts erroneous orbital ephemeris data to create a pseudo range error to prevent adversaries from using the extremely accurate GPS positioning data.

SEMIDIURNAL Having a period or cycle or approximately one-half of a tidal day. The predominant type of tide throughout the world is semidiurnal, with two high waters and two low waters each tidal day.

SEPARATION ZONE

A zone or line separating traffic proceeding in one direction from traffic proceeding in another direction. A separation zone may also be used to separate a traffic lane from the adjacent inshore traffic zone.

SET

The direction toward which a current flows.

SETTLEMENT

Vertical displacement of a moving vessel, relative to what its level would be were it motionless. Settlement is due to the regional depression of the surface of the water in which the ship moves. It is not an increase in displacement. At low speeds the effect of moving the hull through the water causes a local depression in the water surface around the hull. The effect of increasing speed on vessels with planing hulls is to cause them to lift out of the water. Not to be confused with squat which is the change in vessel trim as it moves through the water.

SEXTANT

A double-reflecting instrument used for measuring angles, primarily horizontal angles between two objects when used in hydrographic surveying. The sextant has an arc of 60 degrees, a sixth of a circle, from which it derives its name.

SEXTANT FIX (also called a Three-Point Fix)

A position determined by measuring with a sextant 2 adjacent angles between 3 objects whose relative positions are known.

SHADED RELIEF

A cartographic technique that provides an apparent 3-dimensional configuration of the terrain on maps and charts by the use of graded shadows that would be cast by high ground if light were shining from the northwest.

SHADOW

A light area on a normal sonar record that is less ensonified than the surrounding region; most often caused by signal blocking from an acoustically opaque object on or above the seafloor. Shadows in side scan data are an important aid to accurate record interpretation. Often, an acoustic shadow will divulge more about a reflector than the actual acoustic returns. Shadows are also used to calculate the height of an object standing proud of the seabed. The calculation uses an algebraic solution of similar triangles formed by the height of the towfish, the range to the target and the length of the shadow.

SHALLOW WATER

Water of such depth that surface waves are noticeably affected by bottom topography. Typically, this implies a water depth equivalent to less than half the wave length. Recent usage extends the definition of shallow water seaward to those depths deemed significant to surface navigation – 30 to 40 meters.

SHALLOW WATER MULTIBEAM (SWMB)

A multibeam echosounder system designed specifically for shallow water operations.

SHINGLE

Rounded, often flat waterworn rock fragments larger than approximately 16 millimeters.

SHIPPING LANE

A term used to indicate the general flow of merchant shipping between two departure/ terminal areas.

SHOAL

1.(n) A detached area of any material except rock or coral. The depths over such an area are a danger to navigation, i.e., minimal depths are 11 fm (20 m) or less. Shallow areas consisting of coral or rock are referred to as reefs, rather than as shoals. 2. (verb) To become shallow gradually. 3. (adj.) Shallow.

SHORE

According to riparian law, the land between ordinary high- and low-water marks, where the common law prevails; the land over which the daily tides ebb and flow. The civil law concept of shore has been interpreted as extending to the line of mean higher high tide as it intersects land and some man-made features. See Foreshore and Riparian Boundaries.

SHORELINE

The line of contact between the land and a body of water. On NOAA nautical charts and survey sheets, the shoreline approximates the mean high-water (MHW) line. In OCS, this term is sometimes considered to be synonymous with coastline but the use of the term coastline is discouraged.

SHORELINE MAP

The graphic representation of photogrammetric surveys. The maps contain graphic data relating to the shoreline, and alongshore natural and man-made features, and may include a narrow zone of such features inland from the shoreline. The original sources of a shoreline map are aerial photographs, but may also include ground survey data. Shoreline maps are generated primarily to support hydrographic operations and nautical chart compilation and maintenance. Also called Shoreline Manuscript.

SHORELINE PLANE OF REFERENCE (SPOR)

The vertical datum accepted as the reference plane for shoreline, typically MHW.

SIDE SCAN SONAR (SSS)

A form of active sonar in which fixed acoustic beams are directed into the water perpendicularly to the direction of travel to “scan” the bottom and generate a record of the bottom configuration.

SILL

A submarine ridge or rise of relatively shallow depth separating the sea floor of adjoining basins.

SILT

Sediment particles with a grain size between 0.004 mm and 0.062 mm, i.e., coarser than clay but finer than sand.

SINGLE BEAM ECHO SOUNDER (SBES)

An echo sounder that transmits and receives only one sound pulse at a time; contrasted to a multibeam echo sounder which records multiple soundings over a swath of the seafloor for each transmission. See Vertical Beam Echo Sounder (VBES)

SKEWED PROJECTION

Any standard projection used in map or chart construction, which does not conform to a general north-south format with relation to the neat lines of the map or chart. Alternatively called rotated projection.

SLACK WATER

The state of a tidal current when its speed is near zero, especially the moment when a reversing current changes direction and its speed is zero. The term is also applied to the entire period of low speed near the time of turning of the current when it is too weak to be of any practical importance in navigation. The relation of the time of slack water to the tidal phases varies in different localities.

SLANT RANGE

The straight-path time of arrival of a sonar signal along the hypotenuse of a triangle described by the towfish, the seafloor directly below it, and the seabed point of interest. In side scan sonar, because the imaging source point (transducer) is not on the seafloor but rather above it, slant range does not represent the true range between any 2 objects. Below the towfish, the data is compressed. Farther away from the towfish, the data becomes less compressed, with the least error at the outermost ranges. The near range compression can be corrected for most modern sonar systems.

SLANT RANGE CORRECTION

A computerized repositioning of sonar data on the display to counteract range data compression. See Slant Range.

SLIP

See Dock.

SLIP RING

An electromechanical component, most often used on a winch that allows full electrical continuity of a side scan sonar cable during winch drum operation. Poor quality or dirty slip rings will cause noise in sonar data during drum movement and a bad individual ring can cause a blank sonar channel.

SLOUGH

A small muddy marshland or tidal waterway which usually connects 2 or more bodies of water. See Bayou.

SMALL CRAFT CHARTS

Agency nautical charts at scales from 1:10,000 to 1:80,000 that are designed for easy reference and plotting in limited spaces. In some areas these charts represent the only chart coverage for all marine users. They portray regular nautical chart detail and other specific details of special interest to small-craft operators, such as enlargements of harbors; tide, current, and weather data; rules-of-the-road information; locations of marine facilities; anchorages; courses; and distances.

SMALL SCALE

A scale involving a relatively large reduction in size. A small-scale chart is one covering a large area. The opposite is large-scale. In agency usage, a scale of 1:105,000 (1 inch on survey sheet or chart = 105,000 inches on the ground) or smaller would fall in this classification. See Large-scale survey (chart).

SMOOTH SHEET

The name given to a plotted representation of data acquired during a hydrographic survey. Essentially, it is a record of the soundings taken during the field survey, but historically it contained other data necessary for a proper interpretation of the survey, such as depth curves, bottom characteristics, names of geographic features, and control stations.

SNAG

A tree, tree stump, or tree branch embedded in the bottom of a body of water, thereby constituting a hazard to navigation or to fishing gear, e.g., nets. A snag may be submerged, awash, or visible at mean high water.

SNIPPET

That portion of the backscatter time series that fall within the footprint of an individual beam from a multibeam sonar. This results in a geo-referenced high resolution sidescan image.

SONAR GEOMETRY

The spatial relationship between sonar transducers and their environment, including the seafloor, targets, and the sea surface. Because of acoustic paths in the ocean environment, sonar imagery may be puzzling at times. Accurate data interpretation sometimes requires an understanding of the sonar geometry. A good example of this is when sonar signals return to the transducer over several different paths. See Multipath.

SONARGRAM

A hard copy display of sonar data (typically from side scan) generated either in real time or from recorded data. Also known as sonographs/sonograms, hard copy "records" of side scan sonar data are generated either by a sonar printer, a specialized graphics printer or, with modern computerized sonar displays, by any drafting printer in color or black and white. Early sonar printers used a wet paper technology creating dark and light zones on the paper. Dry paper recorders were developed in the 1970’s followed by thermal paper recorders in the 1990’s. Many sonar manufacturers and users now depend upon digitally recorded data.

SONOGRAPH

See Sonargram. SOUND 1. (n) A relatively long arm of the sea or ocean forming a channel between an island and a mainland or connecting two larger bodies, as a sea and the ocean, or two parts of the same body, usually wider and more extensive than a strait. 2. (v) To measure the depth of the water.

SOUNDING

A measured depth of water; or the act of measuring depth.

SOUNDING LINE

The path followed by a vessel during the acquisition of soundings.

SOUNDING LINE CROSSINGS

The intersection of two systems of sounding lines at which the depths must agree within specified limits. See Crosslines.

SOUNDING MACHINE

A historically used instrument for measuring depth of water, consisting essentially of a reel of wire to one end of which is attached a weight which carries a device for recording the depth. A crank or motor is provided for reeling the wire.

SOUNDING POLE

A graduated pole for sounding in shallow water.

SOUNDING RECORDS

Historically consisted of bound record books in which all of the data taken during a hydrographic survey were entered, and became part of the permanent records of the agency. A typical sounding record of a launch hydrographic survey using an echo sounder and 3-point fix control contained position numbers, times of taking the soundings, uncorrected soundings, corrections to be applied, reduced soundings, boat's headings by compass, position control data, and pertinent remarks. Soundings acquired during a modern survey are routinely filed in digital form. The modern sounding record contains a variety of information, depending on the particular system in use.

SOUND VELOCITY

The rate at which acoustic energy moves through a medium. This term is often used incorrectly instead of the more technically precise term speed of sound. The rate at which sound energy moves through water is a scalar quantity and has no specified direction. Hence, speed is the more correct term since velocity is a vector and implies direction. See speed of sound.

SOURCE MATERIAL

Data of any type required for the compilation of NOAA products including, but not limited to, ground control, aerial and terrestrial photographs, sketches, maps, and charts; topographic, hydrographic, hypsographic, magnetic, geodetic, oceanographic and meteorological information; and intelligence documents and written reports pertaining to natural and man-made features of the area to be mapped or charted.

SOUTHEAST ALASKA DATUM

An independent horizontal datum established toward the end of 1901 by joining together 9 different groups of triangulation to form 1 continuous scheme on one datum. Applied to all triangulation in Alaska between Dixon Entrance and Mount St. Elias.

SPECULAR REFLECTOR

An object to which incident sonar beams are largely normal to its surface, making it a strong reflector from a variety of angles. Objects in this category include cylindrical objects such as pipes and pilings, and spherical objects such as subsurface floats. Specular reflectors may provide very strong sonar returns and will result in hyperbolic shaped lines in side scan data.

The hyperbola is formed when a target is reflective enough to return even the low level energy in the side lobes of the sonar's horizontal beam.

SPEED

Rate of motion. The terms speed and velocity are often used interchangeably, but speed is a scalar, having magnitude only, while velocity is a vector quantity, having both magnitude and direction.

SPEED CORRECTION

The proportional matching of sonar recorder chart length with the over-the-ground speed of the survey vessel. When towing side scan sonar at a constant speed over the bottom, if the image generation on the recorder or display unit is too slow, objects in the data will appear to be compressed in the transverse dimension. If the image generation is too fast, they will appear to be stretched.

SPEED OF SOUND

The rate at which acoustic energy moves through a medium. The speed of sound in sea water is a function of temperature, salinity, and the changes in pressure associated with changes in depth. An increase in any of these factors tends to increase the speed. Often incorrectly referred to as Sound Velocity - velocity is a vector and implies direction and the speed of sound is a scalar quantity as it has no specified direction. See also Speed and Velocity.

SPHERICAL EXCESS

The amount by which the sum of the 3 angles of a triangle on a sphere exceeds 180°.

SPHEROID

A type of ellipsoid which is formed by revolving an ellipse about one of its axes. If the minor axis is the axis of revolution, the resulting figure is called an oblate spheroid (ellipsoid) which approximates the shape of the earth. In geodesy, this term is frequently used to mean reference spheroid.

SPIKE

Sharp deviation from a line, caused by erroneous data or an anomalous event.

SPIRE

A slender pointed structure surmounting a building such as a church. Sometimes depicted as a landmark on nautical charts.

SPIT

A long narrow accumulation of sand or shingle, lying generally in line with the coast, with one end attached to the land and the other projecting into the sea or across the mouth of an estuary.

SPLIT

1. In wire-drag surveying, an area between drag strips not covered by the drag. 2. In hydrographic surveying, one or more sounding lines accomplished between mainscheme lines to provide a more detailed development or to eliminate a holiday in coverage.

SPOIL

Mud, sand, silt, or other deposits obtained from the bottom of a body of water (usually a channel or harbor) by dredging.

SPOIL AREA

An artificial formation created by the deposit of dredged materials on the seabed. Spoil banks that are connected to the natural coastline are part of the baseline from which maritime zones are measured. Those that are unattached are artificial islands and are not part of the baseline. Alternatively, spoil bank.

SQUAT

A change in vessel trim as it moves through the water. This change of level of the bow and stern from a still water condition is in response to the elevation and depression of the water level about the hull resulting from the bow and sternwave systems. Not to be confused with settlement which is the vertical displacement of a moving vessel, relative to what its level would be were it motionless.

SSS

Acronym for Side Scan Sonar.

STACK

A tall smokestack or chimney. The term is used on nautical charts when the stack is more prominent as a landmark than the accompanying buildings.

STAKE

An elongated wood or metal pole embedded in the bottom. A stake plotted on a hydrographic survey is assumed to be wooden unless otherwise annotated. Its diameter is smaller than that of a pole.

STANDARD (for charts)

A file begun about 1908 by means of which a record is kept of all incoming charting information, except aids to navigation. The file consists of a complete set of the published charts. When an individual Standard becomes cluttered with annotations, it is filed and replaced with another chart, which then becomes the contemporary Standard. The file is an invaluable source of historical information and is used in the preparation of project instructions. Also called a Chart Standard.

STANDARD ERROR

The square root of the arithmetic mean of squared deviations from the mean. Also called standard deviation (when the deviations do not represent errors) or root mean square error. In statistics, the standard error is defined as the standard deviation of an estimate. That is, multiple measurements of a given value will generally group around the mean (or average) value in a normal distribution. Standard error is a common measure of the uncertainty associated with a numerical estimate. In a regression analysis, standard errors are often reported with (or below) the coefficient estimates. As a rough rule of thumb, one can be 95% confident that the true coefficient is within ±2 standard errors of the estimate.

STANDARD PARALLEL

A parallel of latitude which is used as a control in the computation of a map projection. For a tangent cone, this is the parallel of tangency. For a secant cone, the two parallels of intersection are the standards.

STANDPIPE

A tall cylindrical structure in a waterworks system, whose height is several times greater than its diameter. It extends from the ground and may be supported by a skeleton-type framework. Sometimes depicted as a landmark on nautical charts.

STATE PLANE COORDINATE SYSTEM

One of the plane rectangular coordinate systems (one for each State in the Union), established by the U.S. Coast and Geodetic Survey in 1933 for use in defining locations of geodetic stations in terms of plane-rectangular Cartesian coordinates.

STATUTE MILE

5280 ft, 1609.3 meters, or 80 chains. Also known as a “land mile” or “English mile.”

STRAIT

A relatively narrow waterway between two larger bodies of water.

STRAND

1. The portion of the seashore between high and low water line. 2. To run aground. The term strand usually refers to a serious grounding, while the term “ground” refers to any grounding, however slight.

STRANDED

The terms “stranded” and “sunken” apply exclusively to items that once were afloat but are now resting on the bottom. “Stranded” items project above the sounding datum, while “sunken” items do not project above the sounding datum. These terms apply most often to wrecks. Masts, funnels, and other extensions of wreck superstructure should be disregarded when applying the above definition; i.e., such features may project above the sounding datum and still have the wreck classified as “sunken.” See Sunken.

STRANDING

The destruction or loss of a vessel by its being sunk or broken up by the violence of the sea or by its striking or stranding upon a rock, shoal, etc. The term stranding refers particularly to the accidental or voluntary driving or running aground of a vessel.

STRUCTURE

The term includes, without limitation, any pier, wharf, dolphin, weir, boom, breakwater, bulkhead, revetment, riprap, jetty, permanent mooring structure, power transmission line, permanently moored floating vessel, pile(s), aid to navigation, or any other obstacle or obstruction.

SUBMARINE CABLE

An insulated, waterproofed wire or bundle of wires for carrying an electric current under water. Such a cable is placed on or near the bottom.

SUBMERGED

Under water; not showing above water (commonly used to refer to features covered at MLLW). This term applies to objects and features that never possessed the ability to float and are now attached to, or resting on, the bottom. All items in this category, except rocks, reefs, and rock or reef formations, are submerged if they are totally below the shoreline datum.

SUBMERGED LANDS ACT

See Public Law 31.

SUBORDINATE GAUGE (Subordinate Water Level Station)

A water level station from which is a relatively short series of observations is reduced by comparison with simultaneous observations from a water level station with a relatively long series of observations.

SUBSIDENCE

Sinking or down warping of a part of the earth’s surface.

SUNKEN

The terms “sunken” and “stranded” apply exclusively to items that once were afloat but are now resting on the bottom. “Stranded” items project above the sounding datum, while “sunken” items do not project above the sounding datum. These terms apply most often to wrecks. Masts, funnels, and other extensions of wreck superstructure should be disregarded when applying the above definitions; i.e., such features may be above the sounding datum and still have the wreck classified as "sunken." See Stranded.

SUNKEN ROCK

A rock potentially dangerous to surface navigation, the summit of which is below the lower limit of the zone for a rock awash. See Rock Awash.

SURDEX

An index of polygons defining the limits of sounding coverage obtained during a hydrographic survey conducted or sponsored by the agency. The figures are contained within a geographic information system. See Survey Indices (Indexes).

SURF

Collective term for breakers. The wave activity in the area between the shoreline and the outermost limit of breakers.

SURVEY

The act or operation of making measurements for determining the relative position of points on, above, or beneath the Earth surface. The result of such operations.

SURVEY INDICES (INDEXES)

Printed sheets showing the dates, areas covered, and scales of planetable and hydrographic surveys along the Atlantic, Gulf, and Pacific coasts to include Alaska and Hawaii. Historically, the indexes were maintained manually, but in more recent times digital technology has begun to replace the system with information maintained in a geographic information system. Also referred to as Surdex.

SWAMP

A tract of stillwater abounding in certain species of trees and course grass or boggy protuberances; a tract of wet, spongy land, saturated, but not usually covered with water; a boggy marshland and stream.

SWATH WIDTH

The lateral coverage of sonar on the seabed. Because a sonar projects a beam(s) laterally to the vessel heading, it creates a wide region of ensonified seafloor. Swath width changes with depth and is a factor in determining coverage and lane spacing.

SWEEP

To drag. "Drag" and "sweep" have nearly the same meanings. In NOAA usage, a drag was typically deployed when the objective was to locate and ascertain the minimum clearance depth over an obstruction. A sweep was used when the objective was simply to verify that no obstructions existed in a channel or waterway. It was not effective in determining clearance depths. See Wire Drag.

SWMB

See Shallow Water Multibeam.

SYSTEMATIC ERROR

Biases in measurement which lead to measured values being systematically too high or too low. All measurements are prone to systematic error. A systematic error is any biasing effect, in the environment, methods of observation or instruments used, which introduces error into an experiment and is such that it always affects the results of an experiment in the same direction. Constant systematic errors are very difficult to deal with, because their effects are only observable if they can be removed. Such errors cannot be removed by repeating measurements or averaging large numbers of results. A common means to remove systematic error is the observation of a known process, i.e. through calibration. Another means to remove systematic error is by a subsequent measurement with more sophisticated experiment equipment.

7.20 T

TABLES FOR A POLYCONIC PROJECTION OF MAPS

Special Publication No. 5, U.S. Coast and Geodetic Survey, contains the true lengths in meters of meridional arcs and arcs of the parallel, as they appear on the Clarke spheroid of 1866, for use in the construction of projections, together with the "x, y " coordinates for plotting the intersection of parallels and meridians in constructing a polyconic projection. The tables are based on the legal value of the meter in the United States, which is 39.3700 inches, and corresponds to 1 m = 3.2808333 ft and 1 ft = 0.3048006 meters. Also referred to as Table of Meridional Parts.

TAGLINE

A line, either marked at equal intervals or run over a registered sheave, used in large-scale surveys to take equally spaced soundings at predetermined distances from a control station or known location, e.g., a pier face.

TANK

In NOAA usage, a fixed structure for storing liquids. Sometimes depicted as a landmark on nautical charts.

TERMINAL MORAINE

A moraine formed across the course of a glacier at its farthest advance, at or near a relatively stationary edge, or at places marking the termination of important glacial advances.

TERRITORIAL LIMITS

The seaward or most offshore limits of a littoral or coastal nation over which it has exclusive jurisdiction.

TERRITORIAL SEA

The water area bordering a nation over which it has exclusive jurisdiction, except for the right of innocent passage of foreign vessels. It extends seaward from the low-water mark along a straight coast and from the seaward limits of inland waters where there are embayments. These waters commonly extend to 12 nautical miles from the coast, per the United Nations Convention on the Law of the Sea.

TERRITORIAL WATERS

Includes the territorial sea (marginal seas) and the inland waters of a country (lakes, rivers, and bays, etc.). Sometimes used as synonymous with Territorial Sea.

TERTIARY GAUGE (Tertiary Tide Station)

A water level station at which continuous observations have been made over a minimum period of 30 days but less than 1 year. The series is reduced by comparison with simultaneous observations from a secondary control water level station. This station provides for a 29-day harmonic analysis.

THEODOLITE

A precise surveying instrument, consisting of an alidade with a telescope mounted so that it can be rotated about a vertical axis; the amount of rotation is measured on an accurately graduated, stationary horizontal circle. See also transit.

THERMOCLINE

A layer of water where the vertical temperature gradient is greater than that in the water above it or in the water below it. Thermoclines affect the ray path of acoustic signals underwater and can result in a range-limiting type of banding visible in side scan sonar data. Similar to the effects of a haline front, this banding is most evident at the outer ranges of sonar data where the beam's angle of incidence to the thermocline is high. Changing the sonar geometry will minimize or eliminate the effects of thermoclines.

THREE-ARM PROTRACTOR

An instrument (metal or plastic) for plotting sextant fixes in hydrographic surveying. It consists of a graduated circle with a fixed center arm and right and left movable arms pivoted at its center so that the extension of each fiducial edge always passes through the precise center of the graduated circle. The observed left angle is set with the left arm and the right angle with the right arm, and each fiducial edge is made to pass through the corresponding control station on the survey sheet. The center of the protractor marks the position of the survey boat.

THREE POINT FIX METHOD

One of the principal methods used historically on inshore hydrographic surveys for establishing the position of the survey boat. It involves the measurement with sextants of two angles between three known stations, the middle station being common to both angles, and plotting the boat's position graphically with a three-arm protractor.

TIDAL BENCH MARK

A bench mark near a tide station to which the tide staff and tidal datums are referred.

TIDAL DATUM

A base elevation used as a reference from which to reckon heights or depths specifically defined in terms of a certain phase of the tide. Tidal datums are local datums and should not be extended into areas which have differing hydrographic characteristics with substantiating measurements.

TIDE

The periodic rise and fall of the water resulting from gravitational interactions between Sun, Moon and Earth. The vertical component of the particulate motion of a tidal wave.

TIDE GAUGE

Also referred to as a water level gauge. A device for measuring actual water levels. It can be a simple as a graduated staff in the water where visual observations can be made or it may consist of an elaborate recording instrument making a continuous graphic record of water levels over time. Until recent technological advances, most tide gauges were actuated by a float in a pipe communicating with the sea through a small hole which filters out shorter waves.

TIDE LANDS

The zone between the mean high-water line and the mean low-water line, commonly referred to as the "beach." Waters above the tidelands are inland, being landward of the coastline.

TIDE RANGE

See Range of Tide.

TIDE STATION

See water level station.

TIME VARIED GAIN (TVG)

A process where amplifier gain is changed based on time and matched with the returning signals between outgoing pulses of a sonar. Because of attenuation of a sonar beam, the receiver gain must be increased as the acoustic returns from greater and greater distances arrive at the transducer. Because these returns are received over a predictable and consistent time, the gains can be increased over a time curve. In many sonar systems, this curve can be adjusted by the operator.

TOP MARK

A characteristic shape secured at the top of a buoy or beacon to aid in its identification.

TOPOGRAPHIC MAP

A map which presents the vertical position of features in measurable form, as well as their horizontal positions.

TOPOGRAPHIC SURVEY

As used in NOAA, a record of a survey, of a given date, of the natural features and the culture of a portion of the land surface and their delineation by means of conventional symbols. Alternately, it is the original field survey sheet and is the authority for the high-water line and all information inshore of that line, including geographic names of topographic features.

TOTAL PROPAGATED ERROR (TPE)

Now referred to as the Total Propagated Uncertainty (TPU), it is an estimate of the uncertainty of any individual sounding, taking into account the error estimates of the component measurements (tide, sound speed, draft, range measurement, angle measurement, attitude, offsets, etc), and expressed as a separate value in horizontal and vertical planes. The uncertainty is sometimes expressed as a variance (in meters2) but more often as a confidence level (in meters) based on the assumption that the uncertainty is a Gaussian distribution. In the latter case, a specification of the level of confidence (e.g., “at 95% CI”’) must be appended for correctness and completeness. Horizontal uncertainties are generally expressed as a single ’Circular Error Probable’ (CEP) value implying a symmetric distribution of uncertainty in the plane. Note that ‘error’ could be considered a misnomer, as there is no implication that the sounding is incorrect, just that its true value is uncertain.

TP SHEET (MAP)

The term "TP Sheet" refers to photogrammetric surveys planned and executed after 1968. Photogrammetric surveys of the "TP" series are graphically depicted in the form of a shoreline map. Shoreline maps of the "TP" series generally depict shoreline in detail. In special survey projects, the shoreline map may consist of the base map and one or more overlays. “TP” stands for Topographic Photogrammetry.

TRACK

The actual path or route of a craft over the ground or sea bottom, or its graphic representation.

TRAINING WALL

A structure built alongside a channel to direct the tidal stream or currents through the channel to promote a scouring action.

TRANSDUCER

The electromechanical component of a sonar system that is mounted underwater and converts electrical energy to sound energy and vice versa. The transducer formation determines the beam shape and is the basis for image formation in side scan sonar.

TRANSFORM

To change the form of data according to specified rules, without significantly changing the meaning of the data.

TRANSIT

A surveying instrument composed of a horizontal circle graduated in circular measure and an alidade with a telescope which can be reversed in its supports without being lifted therefrom. Also, the act of making such reversal. A theodolite having a telescope that can be transited in its supports is a transit, and is sometimes termed a transit theodolite. All modern theodolites are transits. See theodolite.

TRANSVERSE MERCATOR PROJECTION

A projection of the cylindrical type, being in principle equivalent to the regular Mercator Projection turned 90° in azimuth. In this projection, the central meridian is represented by a straight line, corresponding to the line which represents the equator on the regular Mercator Projection. Neither the geographic meridians, except the central meridian, nor the geodetic parallels, except the equator (if shown), are represented by straight lines. It is a conformal projection. Also called transverse cylindrical orthomorphic projection.

TRANSVERSE RESOLUTION

The ability of the sonar to image, as separate and distinct, objects that lay in a line parallel with a side scan sonar towfish track. Transverse or along-track resolution is determined, in part, by the horizontal beam width of the sonar. A narrow beam width will display two targets close together as separate and distinct anomalies. The same two targets, when ensonified by a wider beam, can be simultaneously enveloped by the single outgoing pulse. This can result in the two objects appearing as one in the sonar display. Transverse resolution decreases with range from the towfish because of beam spreading.

TRAVERSE

A route and a sequence of points on it at which observations are made; or the route, the points, and the observations at those points; or the process by which the route and sequence are established. In particular, a survey traverse. Unless specifically stated otherwise, a traverse is horizontal, i.e., a procedure for determining only the horizontal coordinates of the points in the traverse.

TRIANGULATION

A method of surveying in which the stations are points on the ground at the vertices of a chain or network of triangles, whose angles are observed instrumentally and whose sides are derived by computation from selected triangle sides called base lines, the lengths of which are obtained from direct measurement on the ground.

TRILATERATION

A method of extending horizontal control where the sides of triangles are measured rather than the angles as in triangulation.

TRIGGER PULSE

The signal provided to sonar transducer firing circuitry to initiate the outgoing pulse; also, two parallel lines on the center of a side scan sonar record that represent the position of the fish in relation to the sonar image. Many sonar displays sense the trigger pulse in order to synchronize other subroutines with the trigger. Because the display of the trigger pulse in data is caused by transducer firing, it is useful in system troubleshooting.

TRUE NORTH

Geographic or astronomic north; coincides with the true meridian rather than magnetic north.

T- SHEET

Planetable topographic and certain photogrammetric surveys conducted by the agency and its predecessors during the period 1834 - 1980. These surveys were recorded graphically in the form of a map which should be referred to a “topographic survey” or “shoreline map,” as appropriate.

TURBIDITY

Reduced water clarity resulting from the presence of suspended matter. Water is considered turbid when its load of suspended matter is visibly conspicuous, but all waters contain some suspended matter and therefore are turbid. As turbidity increases, the maximum depth that water penetrating bathymetric LIDAR can measure decreases.

TURNING BASIN

A water area used for turning vessels.

TVG

See Time Varied Gain.

TWO POINT FEATURE

A cartographic feature that can be positioned with 1 set of coordinates describing its location and a second set of coordinates defining its orientation.

7.21 U

UNALASKA DATUM

An independent datum in Alaska used along the south coast of the Alaska Peninsula from Cape Kuyuyukak to Umnak Island.

UNITED STATES STANDARD DATUM

The first standard geographic datum adopted by the Coast and Geodetic Survey for all the triangulation in the United States. It was adopted on March 13, 1901, and is defined by station Meades Ranch, whose position on the Clarke spheroid of 1866 is: Latitude 39° 13’ 26.686”, longitude 98° 32’ 30.506”, and azimuth to station Waldo 75° 28’ 14.52”.

UNIVERSAL TRANSVERSE MERCATOR (UTM) GRID

A military grid system based on the transverse Mercator map projection, applied to maps of the earth’s surface extending to 84°N and 80°S.

UPPER LIMIT OF NAVIGATION

The character of a river will, at some point along its length, change from navigable to non-navigable. Very often that point will be at a major fall or rapids, or other place where there is a marked decrease in the navigable capacity of the river. The upper limit will therefore often be the same point traditionally recognized as the head of navigation, but may, under some of the tests described above, be at some point yet farther upstream.

UUV

Acronym for Unmanned Underwater Vehicle. There are two categories of UUVs, AUVs and ROVs. See AUV and ROV.

7.22 V

VALDEZ DATUM

Vicinity of Cape St. Elias to Wide Bay on the Alaska Peninsula, and for the triangulation around Kodiak Island.

VARIATION

The angle between the magnetic and geographic meridians at any place, expressed in degrees and minutes east or west to indicate the direction of magnetic north from true north. Also called magnetic declination.

VELOCIMETER

Same as Velocity Profiler.

VELOCITY

A vector quantity equal to speed in a given direction.

VELOCITY PROFILE

The gradient of acoustic velocity in water displayed as a graph of distance below the sea surface against the speed of sound. This term is often used incorrectly instead of speed-of-sound profile, when referring to a scalar magnitude rather than a vector quantity.

VELOCITY PROFILER

An instrument used for the "in situ" measurement of the speed-of-sound in the sea and other natural waters. Also called velocimeter.

VERIFICATION

As used in NOAA, the process by which a hydrographic survey undergoes a check of the field observations. It deals primarily with a specific survey and its accompanying records, and with correlating it to other contemporary surveys.

VERIFIED WATER LEVELS

Recorded 6-minute water level observations that have undergone both rudimentary data consistency checks in the CO-OPS Data Processing and Analysis System (DPAS) and verification by a technician at CO-OPS. Any gaps in data will have been recovered or interpolated from other gauge data. Verified water levels have been reduced to MLLW.

VERIFIER'S REPORT

The renamed, but approximately equivalent, successor to the "Review Report." On the transfer of the formal hydrographic survey review to the Office of Marine Operations in October, 1975, it was considered appropriate to revise the title of the report, although the format and content remained essentially unaltered. Effective October 1, 1982, the title of this report was again revised to "Evaluation Report." The "Review Report," "Verifier's Report," and "Evaluation Report" are essentially equivalent documents, i.e., they serve the same purpose. See Evaluation Report and Review Report.

VERTICAL BEAM ECHO SOUNDER (VBES)

A term created by NOAA hydrographers to identify the dual-frequency, dual beam width nature of non-multibeam depth measuring sonars. Although the transducer of Vertical Beam Echo Sounders is not gyro-stabilized (a requirement for a true single beam vertical echo sounder) it is assumed that through all vessel motions where depth measurements are taken a portion of the wider beam is indeed vertical. See Single Beam Echo Sounder (SBES)

VERTICAL CONTROL

Term used to describe points with established elevations relative to a specific vertical datum which are used as fixed references for surveying and/or mapping activities.

VERTICAL DATUM

Any level surface taken as a surface of reference from which to reckon elevations. A level surface is one which, at every point, is perpendicular to the direction of gravity, i.e., an equipotential surface. The geoid, or in general, any surface parallel to it, is a level surface. In order that they may be recovered when needed, such datums are referenced to fixed points known as bench marks.

VESSEL

The term “vessel” includes every description of watercraft or other artificial contrivance used, or capable of being used, as a means of transportation on the waters of the U.S.

VESSEL CONFIGURATION FILE (VCF)

A digital file used to set the parameters for sensors and other equipment for data processing. See HIPS Vessel File (HVF)

VESSEL REFERENCE UNIT (VRU)

See Motion Reference Unit (MRU).

7.23 W

W SURVEY

A hydrographic survey originating from outside the administrative control of the agency; alternately referred to as outside source data. These data are considered to have the potential to be applied to nautical charts. They are assigned a registry number consisting of the “W” prefix followed by a 5-digit numerical identifier, e.g., W00001.

WAAS

See Wide Area Augmentation System.

WATER COLUMN

A vertical section of water from the surface to the bottom. Typically used when describing sonar performance, characteristics, and corrections.

WATER LEVEL GAUGE

See Tide Gauge.

WATER LEVEL STATION

The geographic location at which water level observations are conducted. Also, the facilities used to make water level observations. These may include a tide house, tide gauge, tide stall, and tidal bench marks. Also referred to as a tide station.

WATERFRONT

Land at the end of a stream, harbor, etc.; the part of a city or town on such land; a wharf or dock area.

WATERLINE

1. The line marking the junction of water and land. This line migrates, changing with the tide or other variation of the water level. Also written as two words. 2. The line marking the junction of water and the hull of a vessel.

WATERWAY

A water area providing a means of transportation from one place to another, principally a water area providing a regular route for water traffic, such as a bay, channel, passage, or the regularly traveled parts of the open sea. The terms waterway, fairway, and thoroughfare have nearly the same meanings. Waterway refers particularly to the navigable part of the water area. Fairway refers to the main traveled part of a waterway. A thoroughfare is a public waterway.

WAVELENGTH

The distance, measured in the direction of propagation, between 2 successive points in a wave that are characterized by the same phase of oscillation. In sonar technology, along with the transmit power of a sonar, the wavelength (directly related to sonar frequency) will determine the ultimate range of the system. Decreases in wavelength (increases in frequency) bring higher resolution with the tradeoff of reduced range.

WAY POINT

1. A mark or place at which a vessel is required to report or establish its position. 2. A notable point, often the point at which course changes, in a planned vessel route.

WD

See Wire Drag.

WEIR

A fence-like structure set in a stream or along a shoreline to catch fish. It differs from a pound because it is mainly constructed of brush hedging or narrow boards with or without nettings. Coastal weirs are generally built where there is a large expanse of ground left uncovered at low water. Weirs are usually kept in position all year round.

WELL HEAD

A submarine structure projecting some distance above the seabed and capping an oil or gas well on which drilling activity has been temporarily abandoned or suspended.

WHARF

A structure of open, rather than solid, construction parallel to the shoreline, providing only one face, which serves as a berthing place for vessels, and which generally provides cargo-handling facilities. A similar facility of solid construction is called a quay. A structure extending into the water with accommodations for vessels on both sides is called a pier.

WIDE AREA AUGMENTATION SYSTEM (WAAS)

The Wide Area Augmentation System (WAAS) is a network of 25 ground reference stations, ranging from the US to Canada to Mexico, which monitor GPS satellite information and create a GPS correction message. This correction accounts for GPS satellite orbit and clock drift plus signal delays caused by the atmosphere and ionosphere. The corrected differential message is then broadcast through one of two geostationary satellites, or satellites with a fixed position over the equator. A WAAS-corrected signal can result in a GPS positional accuracy of within 3 meters.

WINTER MARKER

A lighted or unlighted buoy without sound signal, which is established as a replacement during the winter months when other aids are closed or withdrawn due to potential severe weather conditions such as ice.

WIRE DRAG

An apparatus once used in hydrographic surveying for determining the maximum clearance depth. It also was used for the detection of isolated dangers to navigation which might escape detection by ordinary sounding methods, e.g., rocks, pinnacles, ledges, boulders, coral reefs, etc. It consisted of a horizontal bottom wire supported at intervals ranging from 300 - 600 ft by adjustable upright cables suspended from buoys on the surface and towed at the desired depth by 2 ships or launches. These uprights could be lengthened or shortened for various required depths. They were kept in a nearly vertical position by means of weights attached to their ends. The end weights and buoys were larger than the intermediate weights, and buoys and the towing gear was attached to them.

WIRE-DRAGGED AREAS

Areas that have been swept to a safe depth with the wire drag. Symbolized on nautical/navigational charts by a green tint.

WIRE-DRAG SURVEY

A hydrographic survey utilizing wire drag apparatus.

WIRE SWEEP

A modification of the wire-drag apparatus. Drag and sweep have nearly the same meanings. The wire sweep was similar to the wire drag, differing only in the length of dragged sections between buoys. It consisted of end buoys and intermediate buoys set at intervals of 2,000 - 2,500 ft. It was used in areas where the general depth was considerably greater than the depths to be investigated and where few, if any, obstructions were believed to exist. The sweep could be set out more quickly and required less equipment than the wire-drag apparatus. The use of the sweep would not necessarily indicate closely the position of any obstruction encountered, due to the great distances between buoys. In addition, the sweep depth would be only an approximation because of the sag of the bottom-wire between buoys.

WORLD GEODETIC SYSTEM 1984 (WGS 84)

WGS 84 is comprised of a consistent set of parameters describing the size and shape of the earth, the positions of a network of points with respect to the center of mass of the earth, transformations form major geodetic datums, and the potential of the earth. It represents the National Geospatial-Intelligence Agency's (NGA's) modeling from a geometric, geodetic, and gravitational standpoint using data, techniques, and technology available in 1984. Satellite positions, including GPS observations, are based on WGS 84 which is both an ellipsoid and a datum.

WRECK

The ruined remains of a vessel which has been rendered useless, usually by violent action of the sea and weather, on a stranded or sunken vessel. In hydrography, the term is limited to a wrecked vessel, either submerged or visible, which is attached to or afoul of the bottom or cast up on the shore. In nautical cartography, wrecks are designated visible, dangerous, or non-dangerous according to whether they are above tidal datum, less than, or more than 20 m (66 ft; 11 fm) below tidal datum, respectively.

WRECKAGE

Goods or parts of a wrecked vessel either washed ashore, afloat, or submerged and resting on the bottom; i.e., the remains of a wreck.

WRECK BUOY

A buoy marking the position of a wreck. It is usually placed on the seaward or channel side of the wreck and as near to the wreck as conditions will permit. To avoid confusion in some situations, 2 buoys may be used to mark the wreck. The possibility of the wreck having shifted position due to sea action between the times the buoy was established and later checked or serviced should not be overlooked.

X

X-AXIS

A horizontal axis in a system of rectangular coordinates; that line on which distances to the right or left (east or west) of the reference line are marked, especially on a map, chart, or graph.

7.24 Y

Y-AXIS

A vertical axis in a system of rectangular coordinates; that line on which distances above or below (north or south of) a reference line are marked, especially on a map, chart, or graph. The line which is perpendicular to the X-axis and passes through the origin.

YARD

A fundamental unit of length in the English system of measurement. The metric equivalent prior to July 1, 1959, was 1 yd = 0.914440183 m. On that date, the value was changed to 1 yd = 0.9144 m.

YAW

An instability characterized by the side-to-side movement of a ship or towed body about its vertical axis. Vessel and towfish yaw most often occur at low speeds and with quartering seas. Towfish yaw is distinctive in sonar data and has an effect on the sonar data similar to the effect of micro-turns.

7.25 Z

“ZERO” SOUNDINGS

Soundings that reduce to heights above the sounding datum but are shown on the smooth sheet as zero soundings, regardless of height; a practice followed prior to 1860.

ZULU TIME

See Coordinated Universal Time.